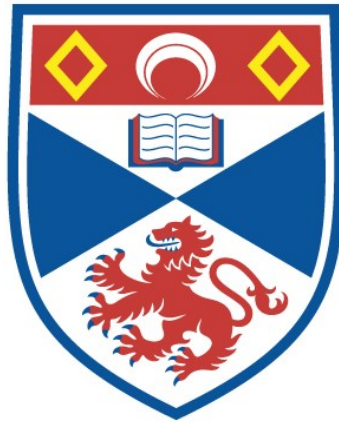


# INVESTIGATING THE LINK BETWEEN INTRUSIVE MEMORIES AND COGNITIVE CONTROL

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*To my parents, without whom this journey would not have been possible.*

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## **Abstract**

Intrusive memories are memories for negative autobiographical events that come to mind without being deliberately recalled (Hackmann, Ehlers, Speckens, & Clark, 2004). Previous research has demonstrated that intrusive memories, and negative reactions to intrusive memories, are an important feature of depression (Starr & Moulds, 2006; Williams & Moulds, 2008b) and contribute to the maintenance of depression longitudinally (Newby & Moulds, 2011c). It has also been established that intrusive memory experience is related to individual differences in cognitive control, specifically in proactive interference resolution (Verwoerd, Wessel, & de Jong, 2009; Verwoerd, Wessel, de Jong, Nieuwenhuis, & Huntjens, 2011). The present thesis aimed to extend upon these existing findings, using the Dual Mechanism of Control theory, which distinguishes between proactive and reactive modes of control (Braver, Gray, & Burgess, 2007). Furthermore, in view of some recent ambiguity of the defining feature of an intrusive memory, as compared to a negative involuntary memory more generally (Kvavilashvili, 2014; Moulds & Krans, 2015), another goal of the thesis was to incorporate a wider focus of involuntary memories, rather than focusing only on traditionally studied intrusive memories. Participants from the student population and local community were tested. Overall, results provide some evidence for a negative involuntary memory related deficit in proactive control, on both a classic and an emotional version of the AX-Continuous Performance Task (AX-CPT). Conversely, there was no link between intrusive or involuntary memory experience and reactive control. A brief mindfulness and self-compassion based intervention, designed to reduce negative reactions to intrusive memories, was also tested. The intervention was successful in reducing intrusive-memory distress, and recommendations for the future development of the intervention are presented.

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# **Chapter one.**

## **Introduction.**

An intrusive memory is a memory for a negative past autobiographical event that comes to mind without being deliberately recalled (Hackmann et al., 2004). Intrusive memories have traditionally been studied in the context of Post-Traumatic Disorder (PTSD), where individuals experience unrecalled memories of a past traumatic event (American Psychiatric Association, 2000). Intrusive memories are experienced either in autobiographical memory or flashback form, where the patient feels like they are back experiencing the original event (Ehlers, 2010). Subsequently, it has been demonstrated that individuals with depression also experience intrusive memories of past negative events (Brewin, 1998; Kuyken & Brewin, 1994). These memories have been shown to be distressing (Starr & Moulds, 2006; Williams & Moulds, 2008b), to be accompanied by ruminative processing styles (Williams & Moulds, 2008b, 2010) and to maintain symptoms of depression longitudinally (Newby & Moulds, 2011b). It is these non-traumatic examples of intrusive memories that are the focus of this thesis.

There has been a plethora of research looking at factors that are important after intrusive memory retrieval in depression. This research has highlighted, for example, that negative appraisals are a common, but maladaptive, response to these memories (Starr & Moulds, 2006; Williams & Moulds, 2008b) and that avoidance behaviours, including suppression and rumination, contribute to the long-term maintenance of intrusive memories (Moulds, Kandris, Williams, & Lang, 2008; Newby & Moulds, 2011c; Williams & Moulds, 2007d). The primary focus of the thesis is to look at the initial *manifestation* of these memories. In particular, the studies presented here aim to determine whether individual differences in cognitive control can explain why some individuals are more susceptible to experiencing these unrecalled memories more

frequently than other individuals. Another objective of the thesis is to test, on a preliminary basis, the use of a mindfulness and self-compassion based intervention to reduce the distress associated with intrusive memories in a low mood sample. This introductory chapter will review the existing work that provides the rationale for the current programme of research, and then summarize the empirical studies that will be presented.

### **What is an intrusive memory?**

As previously described, an intrusive memory is a memory for a negative autobiographical event that comes to mind without being deliberately recalled (Hackmann et al., 2004). Intrusive memories have been conceptualized as unsuccessful emotional processing (Rachman, 1980). Emotional processing is defined as ‘a process whereby emotional disturbances are absorbed, and decline to the extent that other experiences and behaviour can proceed without disruption’ (Rachman, 1980). Therefore, the intrusiveness of cognitions (thoughts, feelings and memories) about the traumatic event in PTSD suggests it has not been fully processed and incorporated into typical memory systems. Similar to the view of Rachman (1980), Horowitz (2003) maintains that thoughts and memories about the event will be experienced both deliberately and automatically until the event is properly integrated. Rachman (1980) proposes that this process of integration is impeded by avoidance behaviours, for example whereby the patient suppresses the memory of the event in order to avoid negative emotions. Accordingly, avoidance of thoughts and feelings or external triggers concerning the memories are included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) criteria for PTSD (American Psychiatric Association, 2000). Research has looked at variables that contribute to the persistence of intrusive memories in PTSD longitudinally. An influential model is the

Ehlers and Steil (1995) model of intrusion maintenance. This model underlines the importance of the appraisals patients give to their intrusive memories. The model maintains that it is the individual's interpretation of their memory, rather than the frequency of the memory per se, that determines the distress experienced. Examples of negative appraisals patients have been shown to endorse include 'If I think about the trauma, I will seriously damage my health' (Ehlers & Clark, 2000). According to the Ehlers and Steil (1995) model, the more negatively an individual appraises their memory, the more distress they experience following the memory. In the short term, this heightened distress prompts avoidance behaviours, for example thought suppression, which increase the frequency of the intrusions (Williams & Moulds, 2008b). Additionally, in the long term, these avoidance behaviours prevent the memory being sufficiently processed (as per Rachman (1980) described above), and also prevent the incorporation of new information to change these appraisals. For example, the individual does not learn that although the memory is upsetting, it does not have to be devastating.

However, intrusive memories are not only experienced by patients with PTSD. Individuals with depression also report experiencing intrusive memories of negative events. This was first established by Kuyken and Brewin (1994), who looked at a sample of females who had experienced childhood abuse. The sample was diagnosed as being clinically depressed, with no other psychiatric diagnoses. The authors found that, in this sample, Impact of Event Scale (IES), a measure of subjective distress, (Horowitz, Wilner, & Alvarez, 1979) were comparable to the IES scores of a sample of patients diagnosed with PTSD. Additionally, participants with high IES scores were also significantly more depressed, measured by the Beck Depression Inventory



(BDI; Beck, Steer, and Brown (1996)) than participants with low IES scores.

Although the sample was screened for PTSD, the sexual abuse experienced by these subjects qualifies as a traumatic event on the Diagnostic and Statistical Manual-IV (DSM-IV) criteria for PTSD (American Psychiatric Association, 2000). This may suggest that results are not necessarily generalizable to a wider sample of depressed individuals. To address this potential confound, therefore, Brewin, Hunter, Carroll, and Tata (1996b) extended these findings to a wider range of negative past events, in a sample of female and male depressed participants. Their depressed sample reported intrusive memories about relationship/family problems, illness/death and work/financial problems. Since these initial investigations, multiple studies have found support for the presence of intrusive memories in clinically depressed (Newby & Moulds, 2011a) and dysphoric participants (Newby & Moulds, 2011b; Williams & Moulds, 2007c). Moulds and Kras (2015) conclude that there is considerable variability in terms of the content of intrusive memories reported by depressed samples, although many pertain to interpersonal events, including relationship problems and arguments. Research has also looked longitudinally at the relationship between depression and intrusive memory experience. Brewin, Reynolds, and Tata (1999) found that IES scores predicted BDI-II scores at 6-months follow-up, after baseline depression scores were controlled for, in a clinically depressed sample. This suggests that intrusive memories play role in the course of depression.

The *content* of an intrusive memory studied within the context of depression is different to the memories studied in PTSD. Specifically, in PTSD the event involves actual or threatened death, serious injury or sexual violence (American Psychiatric Association, 2000). On the other hand, intrusive memories reported by depressed and

low-mood individuals are often memories of commonplace events that most people will have experienced at some point during their lifetime, for example arguments or embarrassing situations (Brewin et al., 1996b; Williams & Moulds, 2007c). However, despite this key difference in the memory content, similarities between intrusive memories in PTSD and depression have been demonstrated. For example, Reynolds and Brewin (1999) found that participants diagnosed with depression and PTSD reported comparable levels of memory vividness and memory distress, although the PTSD patients reported significantly more out of body dissociation when experiencing their memory than depressed individuals. An additional important similarity between the two disorders is the role of the appraisals assigned to the memories. Individuals with depression have been shown to appraise their memory in a negative way, e.g. ‘having this memory means I have a psychological problem’, ‘having this memory means I am inferior to other people’ (Moulds et al., 2008). Accordingly, the model of intrusion maintenance in PTSD, described above, has been validated in depression-focused research. This research will now be summarized.

### **Appraisals of intrusive memories:**

It has long been demonstrated that individuals with depression exhibit biases in the way they perceive and recall emotional information. These include selective attention to negative information (Mathews & MacLeod, 1994), showing either higher recall for negative information or difficulty recalling positive information (Mathews & MacLeod, 2005), overgeneralizing (e.g. summarizing across events rather than recalling a specific event, Williams et al. (2007)), catastrophizing (e.g. excessive focus on the worst possible outcomes, Beck (1979)) and the lack of a self-positivity bias (Dunn, Stefanovitch, Buchan, Lawrence, & Dalgleish, 2009; Watson, Dritschel,

Jentzsch, & Obonsawin, 2008) Consequently, while actually experiencing an intrusive memory in the first place may not be limited to clinical populations, the consequences of these memories may be different. This idea is consistent with Newby and Moulds (2011a), who showed that intrusive memories are not unique to clinical populations. They found no difference in terms of the number of days on which currently depressed, recovered depressed and never-depressed individuals had experienced an intrusive memory the week prior to testing. The currently depressed group did report significantly more occurrences of the memory within the day than the recovered depressed group, who reported levels similar to the control group. However, they did find that there were some elements of the intrusive memories, not related to frequency, which differed between the groups. Specifically, the currently depressed individuals reported higher distress, higher memory vividness, and higher interference than the never depressed individuals. The currently depressed individuals also reported higher levels of interference than the recovered depressed individuals. Depressed individuals also reported higher helplessness and sadness than never depressed individuals, and higher helplessness than recovered depressed individuals.

Starr and Moulds (2006) were the first to look at the impact of negative appraisals of intrusive memories in the context of depression. They used an undergraduate student sample. They showed that dysfunctional meanings of appraisals, measured by the Response to Intrusion Questionnaire (RIQ): Items include ‘something is wrong with me’, ‘I will not achieve future goals that are important’ (Clohessy & Ehlers, 1999), and intrusion-related distress correlated with depressive symptomatology (measured with the BDI-II, Beck et al. (1996)), even after intrusion frequency and event severity were partialled out. Williams and Moulds (2008b) replicated these relationships in a

non-clinical student sample, finding a positive correlation between intrusion-related distress and BDI-II, and between BDI-II, and levels of intrusiveness and avoidance of memory, once again irrespective of memory frequency. These two studies highlight the importance of the reaction to the memory, rather than the initial occurrence of the memory, in samples beyond the original PTSD samples. Findings highlight the importance of the *reaction* to the memory, and suggest that healthy populations react in a different way to similar intrusive memories than clinical populations.

In addition, a great deal of research has looked at the impact of ruminative responses to low mood and general symptoms of depression (Nolen-Hoeksema, 1991; Nolen-Hoeksema, Morrow, & Fredrickson, 1993) and has more recently been looked at specifically as a detrimental reaction to intrusive memories (Williams & Moulds, 2007b; Williams & Moulds, 2010). Rumination is defined as the passive thinking of the causes, meanings and consequence of depressive symptoms (Nolen-Hoeksema, 1991). Therefore while appraisals of intrusive memories specifically concern the memory, rumination refers more inclusively to the general reaction to negative thoughts and feeling down and depressed (e.g. ‘think about all your shortcomings, failings, failures and mistakes’, ‘think about how passive and unmotivated you feel’, Treynor, Gonzalez, and Nolen-Hoeksema (2003)). A wealth of research has highlighted the role of rumination in both the onset and maintenance of depression (Just & Alloy, 1997; Nolen-Hoeksema, 1991). Experimental research has shown that inducing ruminative processing styles, by getting participants to read through a series of ruminative statements, leads to a decrease in mood and an increase in negative cognitive biases (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008) in dysphoric and depressed participants (Nolen-Hoeksema, 1991). Conversely, engaging in a

distraction task has been shown to improve current mood ratings (Lyubomirsky & Nolen-Hoeksema, 1995; Watkins & Teasdale, 2004; Wells & Papageorgiou, 2003).

Further research has demonstrated that there are different components to rumination. One distinction refers to whether the ruminative self-focus has an analytical component (i.e. *why* do I feel like this?) or an experiential component (i.e. *how* do I feel?). Only the analytical component of ruminative self-focus is problematic, whereas an experiential self-focus can have a beneficial impact on mood and cognition. For example, Watkins and Teasdale (2004) demonstrated that inducing depressed participants to an analytical focus, by reading through sentences preceded by the instruction to think ‘about the way you feel inside’, upholds the overgeneral memory bias, a hallmark of maladaptive processing in depression (see Williams et al. (2007) for a review). Conversely, they also showed that inducing an experiential focus, by reading through sentences preceded by the instruction to ‘focus on the way you feel inside’, reduced this overgeneral memory retrieval bias (Watkins & Teasdale, 2004). Watkins and Moulds (2005) additionally demonstrated that an experiential induction improved problem solving in depressed participants, whereas an analytical induction had no impact on problem-solving abilities.

Looking specifically at the relationship between rumination and intrusive memories, Williams (2008) demonstrated that rumination positively correlated with both the number of intrusive memories and intrusion-related distress in a student sample. However the directionality of causation remained unclear from this correlation; it could be that experiencing frequent intrusive memories causes people to ruminate more often, or it could be that rumination contributes to the maintenance of intrusive

memories by preventing more adaptive forms of emotional processing. For example, rumination can be conceptualised as a cognitive avoidance mechanism, as engaging in rumination prevents active problem-solving. Rumination also may reduce the intensity of emotions experienced (Moulds, Kandris, Starr, & Wong, 2007). As argued by the Ehlers and Steil (1995) model of intrusion maintenance, therefore, a ruminative response to an intrusive memory may prevent the integration of the memory into normal memory systems. To investigate this possibility, Williams and Moulds (2007b) used the analytical versus experiential self-focus distinction described above to deconstruct the relationship between rumination and intrusive memories in a dysphoric student sample. They used the film methodology, where participants are exposed to a short film-clip to induce intrusive memories. Film clips are useful in the sense that participants are all exposed to the same event and the same time-point, which standardizes the objective severity of the event, duration of exposure, time since event et cetera. This provides control over the considerable variability in real-life intrusive memories. In this study, dysphoric and non-dysphoric participants watched a sad-movie clip and were subsequently exposed to either an analytical, experiential or distraction processing induction. However, contrary to their predictions, the researchers found that the induction condition had no impact on the frequency of intrusive memories experienced over a five-minute monitoring period. This was despite the fact that the film did successfully induce a negative mood, and that participants did experience intrusive memories about the film. The authors suggest that their null findings were the result of using a film-clip to induce memories, rather than looking at the impact of ruminative processing on real-life intrusive memories. This critique was addressed by Williams and Moulds (2010), who compared the effects of analytical versus distraction inductions on intrusive memories

that dysphoric participants actually experienced in real-life. To assess the impact of processing induction, participants rated aspects of their intrusive memories (including valence, distress and sadness) before and after undergoing the rumination induction. Participants in the analytical condition rated their memories more negatively after the induction than participants in the distraction condition. They also reported a larger increase in intrusion-related sadness and a larger increase in intrusion-related distress pre-to post manipulation in the analytical compared to the distraction condition. These results provide evidence for the causal impact of ruminative processing on intrusive memory experience; analytical rumination exacerbates negative subjective evaluations of intrusive memories. However, the study did not include an experiential self-focus condition (it is unclear why not), therefore no conclusions about the differential impact of experiential versus analytical processing on intrusive memory experience can be drawn.

While this research has provided important insights into what happens after the intrusive memory comes to mind, other intrusive-memory related research has taken a step back to look at cognitive control and whether there is a link between individual differences in cognitive control and the number of intrusive memories experienced. Given that intrusive memories are memories an individual experiences without deliberately trying to recall it, it has been suggested that individuals with ‘weaker’ cognitive control may experience more of these memories than individuals with ‘better’ cognitive control (Bomyea & Amir, 2011). Research in support of this suggestion will now be presented.

**Intrusive memory and cognitive control:**

In our daily lives, we often have to complete effortful tasks in complex and challenging environments. Consequently, we must regulate perception, attention and behaviour in a goal-driven manner. The processes that enable us to do so are referred to collectively within experimental psychology as executive function or cognitive control (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Braver et al., 2007; Miyake et al., 2000). Efficient cognitive control encompasses a diverse set of processes. These include the updating and monitoring information concerning goal-relevancy (Wessel, Overwijk, Verwoerd, & de Vrieze, 2008), the inhibition of goal-irrelevant or distracting information (Banich, 2009; Wessel et al., 2008), adapting after a mistake (Laming, 1968; Rabbitt & Rodgers, 1977) and preparing for future challenges (Banich, 2009; Braver, 2012). Given that intrusive memories come to mind without having been deliberately recalled, or when they are not wanted (Hackmann et al., 2004), it has been suggested that individual differences in cognitive control may be related to intrusive memory experience. Wessel et al. (2008) propose a specific pathway through which cognitive control is important in regulating the experience of intrusions following the experience of traumatic or stressful event. They propose that immediately following the event, the memory is highly active and therefore easily triggered by reminders of the event, both internal (e.g. thoughts or bodily sensations) and external (e.g. seeing a particular person or a movie-scene). Efficient cognitive control during this period of high activation, therefore, would allow an individual to ignore these reminders and continue unimpaired with their goal-driven behaviour. The authors subsequently maintain that repeatedly ignoring these reminders may lower the activation of the memory, thereby resulting in an overall decrease in memory occurrence. Conversely, an individual with less efficient cognitive control would be



less able to ignore any triggers and would therefore continue to experience intrusions on a regular basis.

The initial work looking at potential underlying deficits in cognitive control was focussed on the development of PTSD, with the rationale that while a high proportion of individuals experience an event which would qualify as a traumatic event on the PTSD criteria (67% of college students, Bernat, Ronfeldt, Calhoun, and Arias (1998)), not all of these people will go on to experience PTSD. Despite this, immediately after the traumatic event, many individuals report experiencing intrusive memories and heightened symptoms of mental health difficulties (McNally, Bryant, & Ehlers, 2003) which typically decrease over time. This leads to an important question of whether there are any individual differences that make individuals predisposed to psychopathology following a negative event. The samples used to explore this question have predominantly consisted of university students (Verwoerd, de Jong, & Wessel, 2008; Verwoerd et al., 2009; Wessel et al., 2008). This is in line with the view that research using non-clinical samples is a good starting point for delineating underlying cognitive processes, which can then be translated into clinical populations (Brewin, 1998; Williams, 2008). Because non clinical-samples are used, it is not incredibly important whether the question of cognitive control and intrusive memory experience is conducted within the context of PTSD, or within the context of depression. The underlying question in both examples remains whether individual differences in cognitive control are important in reducing the manifestation of unrecalled memories for negative events. Another bridging feature is that both depression and PTSD-focussed research use the Impact of Event Scale (IES, Horowitz et al. (1979)) to index the subjective distress of the memory. Therefore, this existing

research is highly relevant to the question of cognitive control in the context of intrusive memories experienced in depression.

The first research into individual differences in cognitive control was based on a working memory (WM) model of cognitive control. Working Memory Capacity (WMC) is defined as the amount of information that can be held simultaneously in working memory (Wilhelm, Hildebrandt, & Oberauer, 2013). WMC reflects the amount of information an individual can maintain or keep memory representations in focus (even in the presence of interference), the ability to relocate attention from one representation to another, as well as the ability to manipulate those representations as necessary (Brewin & Smart, 2005). These processes are understood to rely on a supervisory system called the central executive, which controls information from the short-term storage components; the phonological loop and visuo-spatial sketchpad (Baddeley & Hitch, 1974). Baddeley (2000) later added an episodic buffer to the model, which was theorized to be a ‘back-up’ storage system that interacts with all three of the other components. Because WM is a limited-capacity system, the ability to inhibit irrelevant material is important to ensure optimal functioning. Therefore, individuals who are less able to inhibit irrelevant information (e.g. ruminating about recent events) may be vulnerable towards experiencing recurrent intrusive memories. Clinical depression and dysphoria have been associated with general deficits in WM functioning (Channon & Robertson, 1993; Christopher & MacDonald, 2005). These findings are consistent with the difficulties in concentration reported by patients with depression (American Psychiatric Association, 2000). Additionally, Joorman and Gotlib (2008) demonstrated that depressed participants showed a specific deficit in the ability to remove irrelevant negative material from WM, and that this ability was

also related to individual differences in rumination. They conclude that this may have implications for a depressed individual's ability to self-regulate during a negative mood; they may find it difficult to update the content of WM from negative to positive material. In particular relevance to the current thesis, there has been some previous research looking specifically at intrusive memory experience and individual differences in WM. The aim of this work was to determine whether thoughts and memories about stressful life events would take up already limited attentional resources, thereby reducing WMC in people high in life stress. Accordingly, Klein and Boals (2001) established that students with lower WMC (measured by the operation-word span task) reported higher IES scores in relation to a major life event. Brewin and Smart (2005) demonstrated that students higher in WMC reported fewer intrusive thoughts (about an event they reported having frequent thoughts about) during a short suppression task, when they were instructed not to think about that event. However, in the same sample, WMC was not associated with the number of intrusive thoughts reported in everyday life, questioning the generalizability of the laboratory results. It must be noted that working memory is a very general concept. It is unclear from these findings exactly *how* some individuals are predisposed to experiencing intrusive memories, or exactly which mechanisms are involved. One possible extension of the Joorman and Gotlib (2008) WM study described above may be that depressed individuals experiencing intrusive memories are less able to remove information about their negative intrusive memory from WM (even if it is no longer relevant), and therefore they experience the memory more often. This in turn will take up the limited-WMC and result in a cyclical process of continual memory experience. This possibility has not yet been tested, but it is an interesting extension of the existing research. However, one limitation of the WM model of cognitive control is

that it is a very general concept. It is unclear from these findings exactly *how* some individuals are predisposed to experiencing intrusive memories, or exactly which mechanisms are involved. As a consequence of this criticism, additional research looking at the relationship between intrusive memories has specifically investigated the role of proactive interference. This focus is based on the model of cognitive control by Friedman and Miyake (2004). They postulate that cognitive control is dependent on three components; updating, inhibition and shifting. Furthermore, Miyake et al. (2000) argue that it is important to differentiate between different types of inhibition, which are pre-potent response inhibition, resistance to distracting features in the environment, and resistance to proactive interference. Within these subtypes, researchers interested in intrusive memory vulnerability have chosen to focus specifically on proactive interference (e.g. Verwoerd et al., 2009; Wessel et al., 2008). This focus was chosen because proactive interference has been shown to involve the resolution of conflict from internal distractors, including thoughts and memories (Friedman & Miyake, 2004). Therefore, it was hypothesized that individuals with a deficit in proactive interference will be less able to prevent an intrusive memory coming to mind in the presence of triggers. Resistance to proactive interference is defined as the ability to remove information from working memory that is no longer relevant, for example updating a mobile phone number when you buy a new one (Verwoerd et al., 2011). Verwoerd et al. (2011) looked prospectively at the relationship between cognitive control and intrusive memories using the trauma-film paradigm, described earlier in the chapter during the section on memory appraisals. In this design, participants complete the cognitive control task, watch a short film-clip depicting a traumatic or sad event, and then aspects of intrusion experience are measured over a certain time period (typically one week). As mentioned previously,

film clips are useful as they standardize various aspects of intrusive memory experience (e.g. severity of the event, length of exposure, time since event).

Using the film paradigm, in student samples, Wessel et al. (2008) used the AB-AC-AB list-learning task to measure proactive interference and looked at the number of film-related intrusive cognitions (thoughts and memories) that occurred during a 24 hour period after viewing the clip (study 2). Participants retrospectively rated the number of intrusive memories they had experienced over the past 24 hours. In the AB-AC-AB task, participants are given a pair of strongly associated words (the AB list, e.g. butcher-meat) and are asked to learn the pairs so they are able to give the target word (meat) when presented with the cue (butcher). Participants are subsequently provided with a less-strongly related pair of words (the AC list, e.g. butcher-rope) and must now provide this target word (rope) when provided with the cue (still butcher). The number of AB target words given in error at this stage of the task is the measure of proactive interference. The researchers found that better resistance to proactive interference on list 2 was associated with a lower number of film-related cognitions (thoughts and memories) and lower avoidance over this 24-hour period. This suggests resistance to proactive interference might be important in reducing intrusive cognitions. In a separate set of participants (study 1), Wessel et al. (2008) also looked at performance on the random number generation task (RNG). During this task, participants have to provide a sequence of numbers between 1 and 10 as randomly they can. Because participants have to monitor their previous responses in order to keep the following numbers as random as possible, the task measures updating/monitoring and inhibition abilities. Specifically, the researchers indexed updating/monitoring abilities by looking at whether each number was used an

equal number of times during the task. Inhibition was measured by the ability to avoid providing pre-potent responses, including counting, stereotyped responses etc. As a measure of film-related intrusions, participants completed a colour-naming interference task, where they were presented with film-related words (both positive and negative) and had to name the colour of the word as quickly as possible. Results showed that better updating and monitoring on the RNG was related to less interference on the colour-naming task. The authors conclude that this finding supports the idea that cognitive control is important in reducing interference from recent stressful events, in this case a stressful film. However, a different pattern emerged on their diary measure of film-related intrusions, which participants kept for a 48-hour period after watching the film. On this measure, better updating and monitoring on the RNG was associated with a *higher* number of film-related intrusive memories. The authors suggest this may reflect the role of cognitive control in keeping the goal of recording memories in mind, i.e. that participants with better cognitive control are better at remembering to complete their diaries. Conversely, inhibition, as measured by the RNG was not related to intrusive memory experience. In study 2 reported by Wessel et al. (2008), which looked more specifically at proactive interference, participants also completed the RNG task. In this study, intrusion experience was measured retrospectively 24 hours after watching the film, rather than through diary recordings. They found no significant relationship between updating/monitoring abilities and reports of intrusive memories, as reported retrospectively. This discrepancy in results found between the diary and retrospective measure of memories is important to bear in mind. The authors suggest that the diary methodology is affected by participants' capability to adhere to task instructions, and therefore is not necessarily a pure measure of memory frequency. The colour-naming

interference task was also used in study 2, but this time participants completed the task 24 hours after watching the film, rather than immediately after watching the film. In this case, there was no significant relationship between updating/monitoring on the RNG and colour-naming performance; the only significant findings were related to the measure of proactive interference. The authors suggest the null finding concerning updating/monitoring in study 2, as compared to study 1, may reflect that the impact of cognitive control on intrusive memory experience may not specifically work by reducing the activation of the memory. Another potential explanation is that the colour-naming task is not a very sensitive way of measuring the activation of film-memories. Overall, this study supports the idea that intrusive cognition is associated with some degree of deficits in cognitive control, specifically updating/monitoring (study 1) and proactive interference (study 2), and highlights potential issues concerning the different measures of intrusive memories (diary versus retrospective measures).

Also in a student sample, Verwoerd et al. (2011) replicated the finding that individual differences in proactive interference were related to intrusive memory experience, again using the trauma-film paradigm. Proactive interference was measured using the California Verbal Learning Task (CVLT), to determine whether the role of proactive interference would be replicated with a different task to previous research. The CVLT comprises of two lists of words which participants are instructed to encode and then free recall. Some categories overlap between the two lists (e.g. list 1: 10 animals, 10 vegetables, list 2: 10 different animals (an overlapping category), 10 flowers (a new category)). An interference index was calculated by looking at the impact of shared and non-shared categories in list 1 have on list 2 recall performance. The researchers

measured intrusive memories experienced over a week, which participants recorded in a diary. Consistent with Wessel et al. (2008), proactive interference predicted the number of film-related memories experienced during the week; individuals who showed weaker proactive interference recorded more memories in their diary. Importantly, this was not related to previous trauma or depressive symptomatology. Together, these studies support the role of inhibitory deficits, specifically proactive interference, in intrusion experience.

Despite these initial indications that there is a link between cognitive control and intrusive memories, it is important to look at real-life intrusive memories individuals actually experience outside of the laboratory-induced memories. This was highlighted by Williams and Moulds (2010) who looked at the impact of induced ruminative processing styles on intrusion maintenance, both in real-life and laboratory-induced intrusive memories. As discussed earlier in the chapter, there was no difference in ratings of intrusive memories between the analytical and experiential induction conditions on the film-related intrusions (Williams & Moulds, 2007b). The detrimental effects of analytical induction on intrusion experience were only found when looking at memories participants actually experienced (Williams & Moulds, 2010). There were no differences in intrusive memory experience between the analytical and experiential induction conditions on film-induced intrusions. This suggests that cognitive control research should also focus on intrusive memories people actually experience in order to be as sensitive as possible. Consequently, it is these personally experienced intrusive memories that will be studied in the current thesis. Existing research has found differences in cognitive control looking at real-life intrusive memories, again in non-clinical samples. Verwoerd et al. (2009) for



example, asked participants to report on the most distressing event they have ever experienced while they measured proactive interference. Proactive interference was evaluated by the AB-AC-AB list-learning paradigm, described above. The IES was used to index intrusion experience, and participants completed this measure in relation to their memories about their distressing event. As before, results showed that a lower ability to resist proactive interference was associated with higher IES scores. In terms of the other types of inhibition posited by Miyake et al., (2000) it would be interesting to determine whether individuals who experience a high number of intrusive memories also have difficulty resisting interference from features in the environment, for example, external memory triggers such as people and places. It may be that this is another aspect of inhibition that is related to individual differences in intrusive-memory experience. This has not previously been looked at. The Verwoerd et al., (2009) paper discussed above also looked at the relationship between intrusive memories, response inhibition (measured by the Stroop task) and RNG performance, specifically at the ability to avoid automatically triggered pre-potent responses, as measured by the Stoop and RNG tasks. Performance on these tasks was not related to intrusive memory experience, suggesting that prepotent response inhibition is not important in intrusive memory vulnerability.

Together, the existing research on WMC and proactive interference supports the current research goal; there are identifiable deficits in cognitive control in people reporting high number of intrusive memories. The studies presented in this thesis will use a different model of cognitive control; the Dual Mechanisms of Cognitive Control (Braver et al., 2007). However, before that framework is introduced, there is another pertinent finding from the cognitive control literature that may have implications for

the current research goal. Hertel and Rude (1991) propose that the cognitive deficits observed in depression actually reflect difficulty with attentional control, rather than reflecting an overall, generalized, deficit. They consequently showed that depressed individuals were only impaired during an unconstrained (i.e. free learning) task; there was no differences between depressed and non-depressed individuals in a structured (i.e. focused learning) task. They argue that under unconstrained conditions, people with depression are negatively impacted by task-irrelevant processes, for example rumination. This idea is intriguing in respect to work by Berntsen (1998) who demonstrated that involuntary memories most often come to mind when attention is not focused on a particular task (e.g. when bored, tired or when daydreaming). These are similar conditions to those which Hertel and Rude (1991) argue are the most likely to find depressive-related deficits in cognitive control. Together, these lines of research may suggest that people with depression are more prone to intrusive memories when they are not engaged in something specific (e.g. before falling asleep at night), than individuals without a vulnerability to depression. Coupled with a ruminative response style, experiencing an intrusive memory when not busy with a distracting activity may be particularly detrimental to these individuals. This possibility awaits further research.

Furthermore, it is important to highlight that, in addition to looking at behavioural measures of cognitive control, research has also looked at the neuropsychological underpinnings of these deficits and how these relate to depression.

Neuropsychological testing is an important technique used in the diagnosis of clinical disorders, and can provide a wealth of information about rehabilitation, treatment planning and the prognosis of these disorders (Goldberg & Bougakov, 2005). There are established biomarkers of depression, including reduced volume of rostral ACC

(rACC) and the dorsolateral prefrontal cortex (DLPFC) (Pizzagalli, 2001). The ACC is postulated to be important for error detection and cognitive and emotional processing (Bush, Luu & Posner, 2000). The DLPFC is important for a variety of executive functions, including WM processes (Barbey, Koenings & Grafman, 2013), planning (Heinze et al., 2014) and decision making behaviours (Kahnt, Heinzle, Park & Haynes, 2011). Impaired executive functions are one of the fundamental cognitive deficits in depression (Austin et al., 2001), and have been related to both the severity of depression (Paelecke-Habermann et al., 2005) and in predicting poorer response to pharmacological treatment in older patients (Sneed et al., 2007, Alexopoulos et al., 2005). Therefore, it is crucial to understand how these brain areas are affected by factors such as depression. Accordingly, Frodl et al., (2008a) demonstrated that patients with Major Depressive Disorder (MDD) showed a significantly larger increase in rACC and DLPFC volume as compared to never-depressed controls. In addition, smaller rACC volume has also been shown to predict a poorer response to treatment (Chen et al, 2007, Frodl et al., 2008b). Less work has focused on the role of the dACC, and this work has found less consistent results. However, there is some indication that dACC volume reduction is also important in depression. For example, Caetano et al., (2006) demonstrated that unmedicated participants with a past history of MDD showed reduced volume of the dACC. On the other hand, Frodl et al., (2008) found that currently depressed medicated participants showed no dACC abnormalities. This awaits clarification. Nonetheless, this work demonstrates that there are some clear neuropsychological deficits in depression that appear to concern areas important for cognitive control. Given the recent clinical focus on intrusive memories as a symptom of depression, it is necessary to determine whether these established neuropsychological markers of depression are important in intrusive

memory experience, or whether there are any independent markers of intrusive memory vulnerability. For example, as the focus on the relationship between cognitive control and intrusive memory experience grows, it would be interesting to add electrophysical (e.g. electroencephalographic (EEG)) data to the behavioural data to provide a more thorough investigation. EEG data is relatively inexpensive and easy to collect. This type of data would enable researchers to determine whether there are any changes in the brain's electrical activity as a function of intrusive-memory experience. It would be exciting to determine, for example, whether people who experience a high number of intrusive memories respond differently to memory triggers (external or internal) than individuals who do not report as many memories. To my knowledge, there are no existing papers that use electrophysical techniques to investigate this research question. Only behavioural measures of cognitive control are used in the current thesis, but the potential utility of neuropsychological data is important going forward.

The framework of cognitive control for the current program of research will now be presented. As mentioned above, this is based on the Dual Mechanisms of Cognitive Control (DMC). The DMC was proposed by Braver et al. (2007) to account for the flexibility required for optimal cognitive control. The DMC consists of two modes of control; proactive and reactive control. Proactive control is defined as the active maintenance of information prior to a cognitively demanding event, in order to bias attention in a goal-driven manner (Braver, 2012; Braver et al., 2007). Reactive control, on the other hand, is recruited after interference is detected, in a 'late correction' fashion (Braver et al., 2007). As proactive and reactive modes of control both have advantages and limitations, optimal cognition is theorized to rely on

flexible use of both modes. Proactive control is costly to maintain, as the appropriate contextual information has to be maintained over a period of time (Braver, 2012). This continual context maintenance also means that proactive control is less sensitive to potentially important incoming bottom-up information (Braver, 2012). Reactive control, conversely, relies more heavily on the trigger events that reactivate the goal, and requires constant reactivation of the goal. This will be less efficient in situations where context can be adequately predicted and maintained. In terms of the neuropsychological underpinnings of the DMC, proactive control is understood to be sustained by the active maintenance of task-relevant information in the lateral PFC and reactive control reflected through the more short-term activation of the lateral PFC, activated by conflict detection areas, such as the ACC (Braver, 2012, de Pisapia & Braver, 2006). Although a clear picture of the neuropsychological underpinnings is still in progress (Braver, 2012), the utility of the differentiating between proactive and reactive control behaviourally will now be discussed. This work will suggest it is important to establish whether differentiating between proactive and reactive control can provide any additional insight into a potential link between intrusive memory experience and cognitive control, beyond the work already conducted into WMC and proactive interference.

The AX-Continuous Performance Task (AX-CPT) has previously been used to differentiate between proactive and reactive control. The task itself is simple; participants are presented with cue-probe letter pairs presented sequentially. Possible trial types are AX, AY, BX, BY and participants make their response based on the combination of letters presented. Specifically, a ‘target’ response to AX trials, and a ‘non-target’ response to the three other trial types. The task is made more difficult by

the fact that 70% of the trials are AX trials, which biases participants towards making ‘target’ responses to trials with the cue-letter A (incorrect in a AY trial) and trials with a target-letter X (incorrect in a BX trial). Given the disproportionate number of AX trials, which impacts the statistical comparisons that can be made, it is performance to ‘non-target’ trials that is compared. As the correct response to a target-letter depends on which cue-letter was presented, participants must maintain the contextual information presented by the cue letter over the interval between the letter pairs. This reflects proactive control. However, proactive control is not always beneficial on the task. For example, in an AY trial, the cue-letter A would mislead participants into preparing a ‘non-target’ response. Therefore, individuals using a proactive strategy would be impaired in AY trials, but perform well on a BX trial, where they would have use the cue-letter B to prepare a ‘non-target’ response. A deficit in proactive control would also be demonstrated through impaired AX performance. Reactive processing is indexed through target-letter processing. Consequently, participants using a reactive processing style would be impaired by the letter X on a BX trial, but not be influenced by the A on an AY trial. Crucially, the DMC can account for shifts in cognitive control, both within tasks and between populations (Redick, 2014). For example, on the AX-CPT, older adults have consistently been shown to rely more on reactive control than younger adults (Braver, Paxton, Locke, & Barch, 2009; Paxton, Barch, Racine, & Braver, 2008). Additionally, the task has previously been used to demonstrate that individuals with schizophrenia are impaired on BX, but not AY trials, compared to healthy controls (Barch et al., 2001). This demonstrates a specific deficit in proactive control. Differences within the performance of young adults have also been demonstrated. This is important because a young adult sample will be tested in the current thesis. Specifically, Redick and Engle (2011) compared healthy young

participants with low WMC to healthy participants with high WMC. It is important to note that Redick and Engle (2011) did not compare AX performance separately to the other trial types, even though this violates the statistical assumption that each trial type is presented equally frequently. Nonetheless, they showed that low WMC participants made more errors on AX and BX trials, as compared to individuals with high WMC. This suggests a deficit in the use of the context information provided by the cue letter in the low WMC group. This suggests the importance of WMC in maintaining context. The low WMC group were also slower than the high WMC group on AX, BX and BY trials, but not on AY trials. This is consistent with the prediction that using proactive control will impair performance when the expectancy generated by the contextual information (i.e. letter A) is incorrect.

In further support of the DMC framework, it has been demonstrated that, in addition to stable individual differences, reliance on proactive and reactive control can be modified as a function of task specific parameters. For example, Paxton, Barch, Storandt, and Braver (2006) directed older adults to a proactive strategy by explicitly highlighting the high proportion of AX trials and the importance of using the cue-letter to prepare a 'target' response. After this training, older adult performance changed in accordance with a proactive strategy (i.e. more AY errors, fewer BX errors). Braver et al. (2009) extended this finding to show that young adults shifted to more reactive control when they were given monetary penalties for poor performance, and also replicated the previous finding that older adults shifted to a more proactive strategy when trained to attend to the cue. The DMC is able to account for this flexible use of cognitive control. Another study supporting the utility of a dual mechanisms account was conducted by Speer, Jacoby, and Braver (2003). They

manipulated the expected working memory load on a word memory task, and found differences between the conditions both behaviourally and in brain activation patterns. In the task, participants were given a list of words, and after a short delay (3000 ms) had to determine whether a certain probe word had been presented in the original list. In low expected load blocks, list length averaged four words or fewer and it was predicted that participants would engage in an active maintenance-focused strategy (i.e. proactive control). In high expected load blocks, lists averaged eight words or fewer, which was expected to be beyond working memory capacity, and therefore participants were expected to engage in encoding and retrieval-focused strategies after the probe was presented (i.e. reactive control). Probe-decisions to trials containing six words within each block were then compared. Importantly, the number of words was exactly the same, and only the *expectation* differed. As predicted, performance did vary as a function of expected load. Specifically, when the expected load was low, brain activation patterns were consistent with proactive processing (i.e. increased activity over the delay). Conversely, when the expected load was high, patterns were consistent with reactive processing (i.e. decreased activity over the delay and increased activity following probe presentation). Behaviourally, participants were faster and more accurate on the matched six-word trials in the low-load expectancy condition, as compared to the high-load expectancy condition. This supports proactive processing in the low-load condition, as participants maintained the items over the delay period when the expected number of items was lower. These results are evidence that even subtle changes in cognitive tasks can result in a switch between proactive and reactive modes of control.



Returning to the question of cognitive deficits as a function of intrusive memory experience, no research looking at intrusive memories has used the DMC framework of cognitive control. Some work has looked at the impact of low mood on AX-CPT performance. Msetfi, Murphy, Kornbrot, and Simpson (2009) demonstrated that dysphoric student participants were selectively impaired on BX trials when the stimulus onset asynchrony (SOA) between the letter-pairs was long. Conversely, on short SOA trials, dysphoric students' performance was similar to non-dysphoric students. This suggests an inability to retain contextual information over a longer period of time in dysphoric individuals. These results are consistent with the suggestion by Braver (2012) that processes associated with low mood will interfere with proactive control. Importantly, Msetfi et al. (2009) also measured levels of trait rumination and found no effect of rumination on task performance. Other cognitive control research, more general than research based on the DMC, has associated rumination with reduced cognitive control, independently of the strong relationship between rumination and depression (Nolen-Hoeksema, 1991; Nolen-Hoeksema et al., 2008). Whether specifically relating to intrusive memories (Williams & Moulds, 2008b, 2010) or viewed as a general feature of depression (Nolen-Hoeksema, 1991), ruminative processes place a large constraint on cognitive resources and as just stated, has been proposed to specifically impact proactive control processes (Braver, 2012), although this was not supported by Msetfi et al. (2009). Davis and Nolen-Hoeksema (2000) found an association between rumination and cognitive inflexibility, indexed through more perseverance errors on the Wisconsin Card Sorting Task, in a student sample. It has also been demonstrated that rumination is associated with an inability to discard irrelevant negative material from Working Memory (Gotlib & Joormann, 2010). Joormann, Levens, and Gotlib (2011) further showed that rumination was

selectively associated with difficulty manipulating negative words, and not difficulty manipulating positive or neutral words, in currently depressed participants. This work suggests that high trait ruminators may have more difficulty disengaging from an intrusive memory than non-ruminators. This concurs with the importance of measuring trait rumination, and the way individuals react to negative cognitions, when looking at low mood and dysphoric samples. Interestingly, using the word-Stroop task, Altamirano, Miyake, and Whitmer (2010) showed that the effects of rumination and depression on cognitive control to be dissociable in a student sample. On their modified task, only 25% of trials were incongruent, therefore, unless participants actively maintained the colour-naming goal, it would be easy to switch to word-reading behaviour. They found that, after controlling for BDI-II scores, accuracy on incongruent trials positively correlated with RRS scores; high trait ruminators performed better than low trait ruminators. Conversely, when controlling for RRS scores, accuracy on incongruent trials negatively correlated with BDI-II scores; low mood participants performed more poorly. This is especially interesting given the unvalenced nature of their Stroop task, as often valenced tasks are more sensitive at detecting differences. Their results highlight the importance of assessing both depressive symptomatology and trait rumination when assessing cognitive control, rather than assuming that because they correlate highly with each other, they will have a similar effect on cognitive processing. The Altamirano et al. (2010) study is a demonstration that rumination can, in some cases, facilitate performance on a cognitive control task, as high ruminators adhered more to task instructions.

The aim of the current research is to use the comprehensive approach to cognitive control posited by the DMC to determine whether there are fundamental differences

in the trade-off between proactive and reactive control in individuals experiencing a high number of intrusive memories. Consequently, in this thesis, chapters four and five will use the original AX-CPT (described above) to look at cognitive control as a function of intrusion experience. Chapter six expands upon this using the emotional AX-CPT, where the same cue-probe letters are presented on happy or sad faces, which themselves are irrelevant to the task. Assessing performance on emotional tasks of cognitive control is an important addition to the existing research for two primary reasons. Firstly, intrusive memories themselves concern emotional and distressing events. Consequently, it may be that individuals who experience high numbers of intrusive memories are specifically impaired in the ability to inhibit emotional or valenced information. Using unvalenced tasks to assess cognitive control does not address this possibility. Secondly, in most of the literature, intrusive memories are conceptualized as a symptom of PTSD or depression. In the context of depression, both clinical depression and dysphoria have been associated with impaired inhibition of irrelevant mood-congruent material (Joormann & Siemer, 2004), impaired manipulation of negative material in working memory (Joormann et al., 2011) and impaired removal of irrelevant negative material from working memory (Joormann & Gotlib, 2008). Therefore it is important to also look at performance on emotional tasks in relation to intrusive memory experience. For this reason, chapter six will also use the emotional Stroop task as a second measure of cognitive control. The Stroop task is an extremely common task in experimental psychology (MacLeod, 1991) and is a measure of interference. In the classic version of the Stroop, participants are presented with a colour-naming word presented in either a compatible or an incompatible ink colour (e.g. the word RED written in either red or blue ink). Even though participants are not told to attend to the word itself, a consistent finding is that

responses are faster and less error prone on compatible trials as compared to incompatible trials (MacLeod, 1991; Stroop, 1935). In the emotional-face version (Etkin, Egner, Peraza, Kandel, & Hirsch, 2006) participants are presented with either a happy or a sad face, with the word HAPPY or SAD presented below. A variant of the Stroop task can be used to separate performance into proactive and reactive control processes. For example, proactive control can be indexed by comparing performance to blocks where participants are told to prioritize accuracy compared to when they are told to prioritize speed (Saunders & Jentsch, 2014). An ability to respond faster or more accurately as a function of instruction reflects good proactive control, i.e. goal-directed behaviour (Braver et al., 2007). Reactive control can be indexed through congruency sequence effects (CSEs). This is the finding that the Stroop interference effect is typically reduced following an incompatible trial as compared to a compatible trial. This suggests that experiencing conflict increases attentional control and therefore reduces the influence of conflict on the next trial. Verwoerd et al. (2009) did look at classic Stroop task performance, as a measure of response inhibition, as well as proactive interference in the paper discussed earlier in the chapter. However, they predicted that Stroop performance would not be related to intrusion experience. They reasoned that Stroop performance reflects response inhibition, i.e. inhibiting automatically triggered responses, whereas they argued that proactive interference reflects inhibition at a cognitive level, i.e. the inhibition of previously important information. As they predicted, they found no relationship between Stroop task performance and intrusion experience. However, as concluded by Joormann and colleagues, it is important to establish if any differences emerge with the emotional Stroop task. No existing intrusive memory research has looked at cognitive control on emotional cognitive tasks.

## **How special are intrusive memories? Widening the focus to involuntary memories.**

The work summarized so far in this introductory chapter has focused only on intrusive (negative) memories. Whether the research was done in clinical or non-clinical samples, it was conducted with a view to better understand the role of these memories in clinical disorders; the memories have been conceptualized a symptom of PTSD and depression (Ehlers & Clark, 2000; Newby & Moulds, 2011c). There are, however, three important limitations to this focus. Firstly, it has been established that intrusive memories are experienced by student samples (Wessel et al., 2008) and never depressed individuals (Newby & Moulds, 2011a). These results support the view that intrusive memories are not disorder-specific, but instead are a common feature of memory. Secondly, not all involuntary memories are negative in valence. A separate literature, which has looked at involuntary memory more generally, has shown that involuntary memories of positive, negative and neutral event are common, although the specific number experienced does differ both over time and within individuals (Berntsen, 2011). It is important to note that there are some discrepancies in the intrusive/involuntary memory terminology used in the literature, and often lack of clarity about which exact phenomena are being studied (Kvavilashvili, 2014).

Whereas Kvavilashvili (2014) defines an intrusive memory as repetitive memories for past negative events, negative involuntary memories are not necessarily recurrent ('involuntary memories are random, one-off memories, which pop into mind only once or twice', p.101). However, research sometimes uses the terms negative involuntary memories and intrusive memories interchangeably (Brewin, 1998; Deerprouse, Zhang, DeJong, Dalgleish, & Holmes, 2012). This may be a result of the research on intrusive memories in depression having its roots in PTSD research,

where according to DSM-IV criteria, the ‘recurrent and intrusive’ memory (American Psychiatric Association, 2000) specifically concerns the traumatic event. However this intrusive/involuntary ambiguity demonstrates that the repetitive component is not always translated beyond PTSD specific research. For example, Berntsen and colleagues’ research into involuntary memory does not always make a clear distinction between intrusive and negative involuntary memories. This is consistent with Moulds and Kras (2015) who define intrusive memories as ‘distressing memories that come to mind unbidden and unwanted’ (p. 162). They highlight the significance of *subjective judgments* of the memories in rendering the memory an intrusive memory, rather than necessarily containing any repetitive component. Consequently, they argue that what makes an intrusive memory intrusive is that it is recalled without deliberate attempts and that it is upsetting, unwanted and disruptive. While Moulds and Kras (2015) acknowledge the definitions put forward by Kvavilashvili (2014), they support the idea championed by Berntsen and colleagues that both terms represent the same type of memory. To be cautious, however, the work presented in chapters three and five will consider both ‘types’ of negative involuntary memory (i.e. repetitive and not-necessarily repetitive) separately. Specifically, during the Intrusive Memory Interview, participants are asked to retrospectively rate the number of ‘spontaneous’ memories they experienced over the previous week within the context of the same original event, for example an argument with a friend. This is the traditional way intrusive memories are studied in the existing literature (Newby & Moulds, 2011a, 2011c, 2011d; Williams, 2008). Participants also complete the IES in respect to this intrusive memory. It is important to note that the instructions given to participants during the Intrusive Memory Interview make no reference to any repetitive nature of the spontaneous memory. Therefore, it is unclear

whether a participant reporting only one memory over the previous week is necessarily reporting a memory they experience on a regular basis. This is a demonstration of the ambiguity highlighted by Kvavilashvili (2014). In the current research, participants will also complete diary measures of intrusive memories, but the term will not be used with any explicit requirement that the memory is repetitive. Participants will only be told that they should record any memory of a past negative event/circumstance or situation (as per the Intrusive Memory Interview, Hackmann et al. (2004)). Therefore, this frequency measure is only addressing negative involuntary memories in a more general sense, rather than distinguishing between intrusive and involuntary memories. The work presented in the thesis aims to provide a baseline understanding of whether there are individual differences in the experience of intrusive memories, without, in this first exploration, defining how repetitive the memories necessarily are.

Returning to the idea that not all involuntary memories are negative, it has been demonstrated that, in healthy samples, involuntary memories are predominantly positive (Berntsen, 1998; Berntsen & Hall, 2004). Berntsen (1998), for example, found that 49% of involuntary memories recorded in a diary study by a student sample were rated positive (rated as 1 or 2 on a 5-point scale), compared to 19% rated as negative (-1 or -2 on the scale). The remaining 32% of the memories were rated as neutral (0 on the scale). Drawing a similar conclusion, Berntsen and Rubin (2008) asked a non-clinical Danish sample to answer questions about the involuntary memory they had experienced the most frequently over the last year. Contrary to the idea that involuntary memories are experienced only in reaction to negative events, a large proportion of memories were reported to have been either positive (45.4%) or

highly positive (12.7%), while comparatively fewer memories were rated as negative (15.2%) or highly negative (4.7%). In addition, 22% of memories were rated neutral in valence. Even in a sample of students meeting criteria for PTSD on the self-report Post-Traumatic Stress Diagnostic (PDS) questionnaire, Berntsen (2001) found that the frequency of negative and positive involuntary memories recorded was almost equal (39% versus 40% respectively). Indeed, 78% of the involuntary memories recorded by this sample did not even concern the traumatic event participants had experienced, once again questioning the view that involuntary remembering prioritizes extraordinary memories. A limitation to the interpretation of this study is that they used a method designed to ensure, as far as possible, that the memories were genuinely involuntary, rather than resulting from task demands. In this method, participants are asked to record only the first 2 involuntary memories they experience on any day, until they have recorded a total of 50 memories. Consequently, a full picture of involuntary remembering is not addressed by this methodology, and no conclusions about the exact proportion of trauma-related memories as a total number of memories experienced can be made. It has also been demonstrated that low mood populations do experience positive involuntary memories. For example, Watson, Berntsen, Kuyken, and Watkins (2012) established that individuals with depression also experience *positive* involuntary memories. In their depressed sample, 34% of involuntary memories recorded in a diary were negative, 50% were positive and 15% were neutral (Watson et al., 2012). These are clear indications that involuntary memories do not consist exclusively of negative events. In fact, Berntsen (1996) suggests that intrusive memories are not conceptually different to more general involuntary memories. Instead, she argues that intrusive memories form part of a normally functional memory system. While intrusive memories may develop into something problematic,



for example, if experienced habitually, or as a reaction to extremely stressful events (Rasmussen & Bernstein, 2009), that is not to say the involuntary memory system is fundamentally maladaptive (Berntsen, 2011). Consequently, Berntsen (2011) argues that the high accessibility of memories that have been traditionally studied in clinical populations can be attributed to factors which apply to both voluntary and involuntary memory recall; known as the basic mechanisms view (Berntsen, 2011). This basic mechanisms view maintains that involuntary memories adhere to the same principles of encoding and maintenance as voluntary memory. For example, research has demonstrated that involuntary memories have a greater emotional impact than voluntary memories (Berntsen, 2011; Berntsen & Hall, 2004; Rubin, Boals, & Berntsen, 2008). However, this effect is attributed to fundamental differences in the way involuntary and voluntary memories are retrieved (Berntsen, 2011). Because an involuntary memory pops into mind suddenly, there is no opportunity to engage in pre-emptive emotion regulation (Gross, 2001), for example by reappraising or down regulating a negative memory before it comes to mind. This finding may account somewhat for the association between reports of intrusive memories and heightened levels of distress, without meaning that intrusive memories are fundamentally different to memories for non-traumatic or non-distressing events.

The third rationale for looking more generally at involuntary memory and cognitive control, rather than focusing only on negative memories, comes from work on the effects of positive voluntary memory recall in low mood individuals. The effects of depressed mood on voluntary remembering have been well documented; memories of negative events are more easily accessible (Clark & Teasdale, 1982, 1985; Lloyd & Lishman, 1975) and individuals with depression report fewer memories for specific

events than individuals with no depression (Williams et al., 2007; Williams & Dritschel, 1988). However, it has been demonstrated that individuals vulnerable to depression also react to *positive* material in a different way to healthy populations. Accordingly, Joormann and Siemer (2004) showed that dysphoric individuals reported no increase in mood following positive memory recall, whereas non-dysphoric individuals did report an increase in mood. Most interestingly, Joormann, Siemer, and Gotlib (2007) demonstrated that recalling a positive memory resulted in a decrease in current mood in currently depressed individuals, whereas the mood of never-depressed individuals improved. Therefore, positive involuntary memories, and reactions to positive involuntary memories, may also be important in clinical disorders, a view supported by Moulds and Kras (2015). In conjunction, these findings indicate that the clinically-focused literature does not investigate the full picture of memories that come to mind without being deliberately recalled; looking only at intrusive memories in the clinical context may be too blinkered a view. This has implications for the research looking at cognitive control. By focusing only on memories for *negative* life events, predictions are formed in terms of deficits that make people more vulnerable to these memories, implying that involuntary memories are always unwanted or always problematic. Chapter five challenges the narrow focus on intrusive memories by looking at whether there is a link between cognitive control and all kinds of involuntary memories reported by participants; the ability to regulate the occurrence of unrecalled memories may not depend on the valence of the memory. This is an important step in bridging the gap between the clinical literature and the more general involuntary memory literature, which argues that involuntary memories represent a basic mode of remembering (Berntsen, 2010). This goal is also consistent

with Brewin (2014), who highlights the importance of investigating how ordinary mechanisms of memory operate in unusual circumstances.

### **Interventions targeting intrusive memories:**

The research summarized at the beginning of this introductory chapter implies that targeting negative reactions to intrusive memories would have a beneficial impact on well-being in depression. Despite this, treatment programmes specifically addressing intrusive memories in depressed samples are underdeveloped (Newby, Lang, Werner-Seidler, Holmes, & Moulds, 2014). In contrast, the most effective treatments for PTSD involve repeated exposure to the trauma memory (Ehlers, Clark, Hackmann, McManus, & Fennell, 2005). For example during imaginal exposure, patients are encouraged to revisit the event in first-person narrative on multiple occasions.

Another example of treatment specifically addressing the intrusive memory in PTSD is the writing of a trauma narrative and/or cognitive restructuring of the event during Cognitive Behavioural Therapy (CBT) (Ehlers & Clark, 2000; Ehlers et al., 2005). In the context of depression, Kandris and Moulds (2008) used a single case study to test the efficacy of imaginal exposure in a male experiencing a current episode of depression, which at the onset of the study had lasted four months. The treatment involved five 90-minute weekly sessions, during which the man was encouraged to relive the event, which consisted of an argument with his ex-partner, in the first-person narrative. It also included some elements of psychoeducation. Treatment reduced the frequency and distress associated with the patient's intrusive memories, and improved mood to the extent that the participants no longer met criteria for a current episode of depression after treatment completion. However, more relevant to the goal of the current thesis, Lang, Moulds, and Holmes (2009) demonstrated that appraisals of intrusive memories can be modified, and importantly, that modifying

appraisals has an effect on intrusion experience. They used Cognitive Bias Modification (CBM), during which participants are repeatedly exposed to positive or negative resolutions to ambiguous situations in order to train interpretations (Cristea, Kok, & Cuijpers, 2015; Joormann, Waugh, & Gotlib, 2015). Lang et al. (2009) exposed an undergraduate sample to either 72 positive or negative appraisals (e.g. having an intrusive memory means nothing/something is wrong with me') who then, after the CBM induction, watched a traumatic film-clip. Participants in the positive appraisal condition subsequently reported fewer intrusive memories of the film over the following week, reported lower levels of intrusiveness and avoidance (as measured by the IES) as compared to participants in the negative appraisal condition. Building on these findings, Woud, Holmes, Postma, Dalgleish, and Mackintosh (2012) showed similar results when student participants were inducted to positive appraisals after watching the film, rather than before the film, as done by Lang et al. (2009). These results demonstrate the benefits of specifically targeting appraisals. Newby et al. (2014) extended upon these results by testing the impact of positive appraisal CBM training (consisting of 72 positive statements, e.g. 'intrusive memories mean I can cope' and 8 neutral statements 'e.g. 'intrusive memories pop into my mind spontaneously') on personally experienced negative intrusive memories in a dysphoric sample, some of whom met criteria for a current episode of depression. This intervention was compared to a single-session education-based intervention. In the latter condition, participants were given information about intrusive memories. For example, they were told that intrusive memories are experienced by many people. Participants also took part in exercises to challenge their negative appraisals (e.g. that thinking about the memory would interfere with any task they tried to complete) and in a short thought suppression experiment, in order to demonstrate the often

paradoxical effects of thought suppression (Wegner, 1994; Wegner, Schneider, Carter, & White, 1987). This work demonstrates that trying to suppress a particular thought can actually increase the number of times the thought is experienced. There was also a third no-intervention control group. Each group contained 20 participants. At one week follow-up, they found reductions in depression and anxiety, intrusiveness of the memory (measured by the intrusiveness subscale of the IES) and negative appraisals across all three groups. These reductions were greatest in the education group, followed by the CBM group. However, contrary to predictions, there was also an effect in the no-intervention control group. This maybe a result of the self-report questionnaires normalising the experience of intrusive memories and is important to bear in mind for any research investigating the impact of future interventions. The authors also found that reductions in negative appraisals positively correlated with reduction in intrusion-related distress (measured by the total IES score). Results of this study demonstrate the initial potential efficacy of interventions addressing the reaction to intrusive memories, but the selective nature of such interventions requires further study. It is also important to more extensively investigate the changes observed in the no-intervention control group. The third chapter of this thesis extends upon this finding by testing the efficacy of mindfulness and self-compassion based intervention to reduce the impact of negative appraisals. The intervention aims to target emotional reactivity and implicitly teach participants to react differently to their memories, without getting caught up in a negative cycle of appraisals. The concepts of mindfulness and self-compassion, and research in support of these interventions, will now be introduced.

### **Mindfulness, self-compassion and the benefits of a mixed intervention:**

Mindfulness is defined as ‘paying attention in a particular way: on purpose, in the present moment, and non-judgmentally’ (pg. 4, Kabat-Zinn (1994)). The origins of mindfulness stem from Eastern meditation practices (Baer, 2003), but within psychology, mindfulness is practiced without any religious nuances. During mindful practice, individuals are encouraged to tune into their current experience, without trying to judge or change thoughts or feelings that come to mind. Using the body as an anchor, individuals are encouraged to begin notice when their attention wanders, and how to bring their focus back to their internal experience, for example by focusing on the breath. Higher trait mindfulness, as measured by the Mindful Attention and Awareness Scale (MAAS, Brown and Ryan (2003)) has been associated with lower levels of depression, as measured by the BDI-II, and anxiety, measured by the State-Trait Anxiety Inventory (STAI, Spielberger, Gorsuch, Lushene, Vagg, and Jacobs (1983)) in a student sample. Yeung (2013) replicated this finding, demonstrating that trait mindfulness, measured by the MAAS, was negatively correlated with symptoms of depression and anxiety, measured by the Hospital Anxiety and Depression Scale (HADS), in a student sample.

Mindfulness has, in several variants, been incorporated into psychological interventions to improve well-being. Mindfulness-Based Stress Reduction (MBSR) was originally designed to help people with chronic pain and a variety of issues that were difficult to care of in a hospital setting (Kabat-Zinn, 2003). The programme consists of 8-10 weekly group sessions and one full intensive mindfulness day. The course combines mindfulness meditations with some yoga exercises. Participants are encouraged to talk about their experiences of the exercises within the group. In a large

systematic review of 26 studies (involving over 1,900 participants, both clinical and non-clinical), Vibe, Bjørndal, Tipton, Hammerstrøm, and Kowalski (2012) conclude that MBSR has a moderate and consistent beneficial effect on mental health.

Mindfulness-based Cognitive Therapy (MBCT) built upon the foundations of MBSR and was specifically designed for individuals experiencing recurrent episodes of depression, in remission at the beginning of the programme. MBCT is based on a model of depressive relapse and combines elements of mindful practice with elements of Cognitive Therapy (Teasdale, Segal, & Williams, 1995). According to the depressive relapse model, experiences of low mood, which may be transient in healthy individuals, are more likely to spiral into long-term experiences of depression in people who have experienced previous depressive episodes. Therefore, mindful practice helps individuals become more aware of negative patterns of thoughts and, through repeated practice, learn how to disengage from these thoughts before they kick off a ruminative cycle and contribute to more extended experiences of low mood. Participants are also encouraged to decentre from these negative thoughts, recognising that they do not necessarily reflect reality (Teasdale et al., 1995) and that these negative thoughts are simply mental experiences that will come and go (Baer, 2003).

Specific elements of CBT are also incorporated into MBCT; participants are taught about the effects of depression on cognition (for example, the role of negative interpretative biases on mood) and the relationship between emotions, behaviour and physiology (van der Velden et al., 2015). The format of MBCT is similar to MBSR; it involves 8 weeks of group sessions, a full one-day retreat and homework in between the sessions. Initial randomized control trials (RCTs) into MBCT indicated that the programme successfully reduced relapse in participants with 3 or more previous episodes of depression. However, in participants who had experienced only 1 or 2

previous episodes, there was either no reduction in relapse rate (Teasdale et al., 2000), or an increase in relapse rates (Ma & Teasdale, 2004), as compared to a treatment-as-usual (TAU) condition. The selective efficacy in patients with 3 or more previous episodes of depression was further shown by Ma and Teasdale (2004) to be associated with key differences in characteristics between the two groups. Specifically, MBCT was most beneficial in reducing relapse in the participants whose depression was not triggered by a negative life event, but instead in cases where the relapse was triggered by internal processes, including rumination. Therefore, Ma and Teasdale (2004) conclude that MBCT is highly effective at reducing the impact of ruminative negative thinking on downward spirals in mood. This supports the investigation of mindfulness-based interventions (MBIs) to reduce negative reactions to intrusive memories. However, these results are clear evidence that MBCT is not effective in all populations. Therefore, other variants of Mindfulness-based interventions (MBIs) have been investigated, in more general samples, including non-clinical populations. These samples are similar to the sample tested in the study presented in chapter 3. For example, Heeren and Philippot (2011) adapted MBCT to be suitable for subclinical participants with a mix of stress, anxiety and depressive symptoms. Consequently, instead of just being told specifically about depression, participants were given more general information about mental well-being. Changes were compared to a waitlist control group. The mindfulness group showed a significant decrease in general symptomatology (measured by the global score index of the Symptom Checklist-90-R) and a significant decrease in rumination, as compared to the waitlist control group. Additionally, changes in rumination mediated the effects of the intervention on general symptomatology, again supporting the idea that rumination is one component being changed in mindfulness training. However, these changes were only assessed



against a waitlist control, therefore it is unclear to what extent the benefits were treatment-specific, or whether they reflected non-specific factors, such as contact with researchers, social effects of participating in a study. In further support of the benefits of mindfulness in more general samples, beyond the selective impact of MBCT, mindfulness interventions have been shown to be effective in enhancing psychological well-being in community volunteers (Williams, Kolar, Reger, & Pearson, 2001), university student samples (Danitz & Orsillo, 2014; Shapiro, Schwartz, & Bonner, 1998), and adolescents (Tan & Martin, 2015). These studies are indications that MBIs, more general than MBCT, can be effective in more extensive samples than the previous selective efficacy of MBCT in participants with 3 or more previous episodes of depression.

Shorter mindfulness interventions have also been shown to be effective. This is an important finding as the considerable time commitment involved in a traditional mindfulness courses described above, typically 8 weeks, may deter people from beginning a traditional mindful course (Tappen, 2014). For example, Cavanagh et al. (2013) reported improvements in stress, anxiety and depression in a large student sample following an online mindfulness training course. Participants were given access to a 10-minute meditation and encouraged to listen once a day for a period of two weeks (they were sent reminder emails every 3 days). The effects were compared to a waitlist control group. Levels of stress, anxiety and depression significantly decreased in the mindfulness group, and remained unchanged in the control group. However, consistent with the idea that attrition is a large problem in mindfulness interventions (Crane & Williams, 2010), there was a large attrition rate in this study. Almost half of the mindfulness group dropped out of the study before completing the

final questionnaires, although there was no face-to-face contact required to participate. Consequently, results could be somewhat the result of a sample selection bias, where only certain participants completed the course. The intervention presented in this chapter is more extensive than this online study, as participants were exposed to more than one short mindfulness exercise, but still shorter than traditional longer programs. The study tested during this thesis also involved personal contact rather than being an online study, which may enhance the acceptability to participants and address the attrition issue. The intervention presented here lasts three weeks. In addition, participants were encouraged to follow guided exercises on a daily basis, should the benefits of the Cavanagh et al. (2013) study result from the regularity of the practice.

Overall, the existing research supporting mindfulness-based interventions shows some promise, although it has been demonstrated that mindfulness interventions are not always effective, and the lack of control group is problematic. Additionally, less work has looked at exactly *how* mindfulness works (Baer, 2011; van der Velden et al., 2015). Understanding the mechanisms underlying the favourable effects is important, both to best understand which populations would benefit from a proposed intervention, and to optimise the training protocol used for that particular sample (Teasdale, Segal, & Williams, 2003). Accordingly Teasdale et al. (2003) caution against simply viewing mindfulness as a ‘cure-all’ intervention; it is important to predict exactly *how* mindful practice would help a particular population. As described above, the premise of mindfulness is that practice reduces the potency of negative thoughts or experiences by helping individuals to learn to notice, and then disengage from them, before getting caught up in a negative ruminative cycle

(Teasdale et al., 2000). There is empirical support for this proposition. In a sample of individuals with lifetime mood disorder, mindfulness training reduces rumination, after controlling for changes in affective symptoms and dysfunctional beliefs (Ramel, Goldin, Carmona, & McQuaid, 2004). Returning to the idea that rumination consists of different subtypes, Heeren and Philippot (2011) demonstrated that MBCT training increased what they termed ‘adaptive’ rumination (discussed earlier in the chapter as experiential self-focus; a focus on *how* I feel ) and decreased maladaptive rumination (described earlier as analytical self-focus; a focus on *why* I feel this way). Moreover, the authors demonstrated that changes in rumination mediated the reductions in general symptomatology, thereby suggesting that the changes in rumination are an integral part of the benefits of mindfulness. This proposal has implications for the proposed intervention. It has consistently been demonstrated that it is not the initial experience of the intrusive memory that is problematic, but instead the *reaction* to the memory. This suggests that mindful practice would be beneficial to individuals prone to negative reactions to an intrusive memory (e.g. ‘having this memory means something is wrong with me’, Kandris and Moulds (2008)). In accordance with Teasdale et al. (2003), this reflects a specific application of mindfulness based on an understanding of one major contributing factor to distress; in this case, the impact of general depressive rumination widened to include reactions specifically to intrusive memories. This potential has not previously been investigated.

Existing mindfulness interventions are being modified to also incorporate aspects of self-compassion. Like mindfulness, self-compassion also has roots in Buddhist traditions (Neff, 2003a). While it has been suggested that self-compassion is implicit in mindful practice, it will be argued that there are specific benefits of making self-

compassion explicit. Neff (2003a) defines self-compassion as ‘generating the desire to alleviate one’s suffering and heal oneself with kindness’ (p.87). The premise of self-compassion is to treat yourself the same way you would treat a friend or loved one who was going through a difficult time; with kindness, support and understanding (Neff & Dahm, in press). Neff (2003a) proposes that self-compassion is made up of three inter-related constructs: i) self-kindness, being kind and understanding instead of being critical and judgemental, ii) common humanity, viewing our individual experiences as a wider part of the general human experience, iii) mindfulness, maintaining a balanced awareness, reducing the need to avoid, suppress or over-identify with our personal experiences.

Correlational studies, conducted in non-clinical samples, have shown that higher levels of self-compassion are associated with lower levels of anxiety, depression (Leary, Tate, Adams, Allen, & Hancock, 2007; Neff, 2003b) and rumination (Neff, 2003b; Neff & Vonk, 2009). Levels of self-compassion have also been shown to be associated with higher levels of positive affect, happiness and optimism (Neff, 2003b; Neff, Kirkpatrick, & Rude, 2007). In addition, first-year university students who rated themselves higher in self-compassion at the beginning of the semester reported less homesickness and lower levels of depression at the end of the semester (Terry, Leary, & Mehta, 2013). Furthermore, Neff et al. (2007) demonstrated that high levels of self-compassion were associated with a lower increase in anxiety in an undergraduate sample asked to write about their greatest weakness in a mock job interview. This task was designed to induce high stress levels and suggests self-compassion is protective against distress in times where a positive view of the self is challenged. Leary et al. (2007) drew a similar conclusion when exploring the relationship between self-

compassion and reactions to real-life and hypothetical life events. Hypothetical events were looked at in addition to real-life events to ensure that any differences were not simply attributable to the type of events people high versus low in self-compassion are reporting. For both types of events, high self-compassion was associated with lower negative emotions. Individuals high in self-compassion also ruminated less when presented with negative evaluations of themselves. In light of the demonstration that higher self-compassion has been associated with lower levels of anxiety and depression (Leary et al., 2007; Neff, 2003b; Neff et al., 2007), Raes (2010) looked at the mediating effects of rumination and worry on the relationship between self-compassion, depression and anxiety in an undergraduate sample. Rumination and worry both represent negative repetitive types of thinking, in depression and anxiety disorders respectively. Therefore, Raes (2010) hypothesized that the positive implications of being self-compassionate may come about through a reduction in these detrimental negative thinking styles. As per Treynor et al. (2003), they further subdivided rumination into brooding (negative and passive reflection on the current situation) and reflection (a more neutral type of reflection) subtypes, using the Ruminative Response Scale (RRS). Their analysis confirmed that the brooding subscale of the RRS mediated the relationship between self-compassion scores and BDI-II scores. In addition, both worry and brooding scores significantly mediated the relationship between self-compassion and anxiety. This is initial evidence of *how* being self-compassionate is beneficial; it may reduce the impact of repetitive negative thinking about oneself. This has implications for the current proposed intervention. Certain individuals have been shown to endorse the belief that having an intrusive memory infers something negative about themselves, for example, that they are weak or inadequate (Moulds et al., 2008). This is an example of an uncompassionate

response and supports the prediction that individuals prone to self-deprecating reactions to intrusive memories would benefit from being more self-compassionate.

Like mindfulness, it has been shown that self-compassion can be increased through interventions. For example, Compassionate Mind Training (CMT) was developed for people with high levels of shame and self-criticism with a mixture of chronic psychological problems (Gilbert & Irons, 2005). The premise of CMT is that there are two processing pathways, a self-judgmental one and a self-kind one. The intervention is designed to help individuals change the way they relate to themselves by activating the self-kind pathway through a variety of exercises. A key component of the intervention is the generation of compassionate imagery, during which participants are encouraged to create and explore their ideal compassionate image, and use this image to help adopt a more compassionate stance towards themselves. Another exercise is writing a compassionate letter to themselves, written as if it were from the chosen compassionate image. Gilbert and Procter (2006) conducted a small 'pre-trial' study on CMT (N = 6) in participants attending a CBT day centre for patients with long-term psychological difficulties. They found significant reductions in depression, anxiety, shame and increases in participants' self-rated ability to be self-compassionate following twelve two-hour sessions. This was the first evidence of the potential effectiveness of a compassion-based intervention. Smeets, Neff, Alberts, and Peters (2014) tested the effectiveness of a shorter three-week self-compassion intervention in non-clinical female college students. This reflects a similar sample to the one used in chapter three. The intervention in the Smeets et al. (2014) study consisted of two one and a half hour sessions designed to help the students cope with the demands of college life in a more self-compassionate manner, plus a follow-up

week session. During the first session, participants were introduced to the concept of self-compassion and were encouraged to write down their most common self-critical thoughts. The homework consisted of three components. Participants were given an ‘intervention bracelet’, which they were told to move from one arm to the other anytime they reacted un-compassionately to a negative event. They also kept a ‘self-compassion’ journal, which encouraged self-compassionate responses to challenging situations and were asked to practice three loving-kindness statements daily. Loving-kindness is the practice of unconditional kindness and loving acceptance towards all beings and the self, for example ‘may the person be free of suffering’ (Hofmann, Grossman, & Hinton, 2011). During the second session, participants devised three self-compassionate phrases to practice during the week, and were asked to write down five things they appreciate about themselves. As homework over the following week, participants were asked to write themselves a compassionate letter about a negative issue, written as if they were writing to a friend. The control group completed sessions in time management skills, matched for the number of sessions and homework assignments (e.g. keeping records of their time efficiency). The self-compassion group reported significantly greater increases in both self-compassion and mindfulness than the control group. The increases in mindfulness are particularly interesting given that participants did not complete any explicit meditative mindfulness exercises. This result further supports the interplay between mindfulness and self-compassion that was discussed above. Consequently, training in one practice may enhance the other, even if the other practice is not an explicit focus. The compassion group also reported decreases in rumination, and increases in ratings of self-efficacy and optimism. Results from this study demonstrate that a short self-compassion intervention can be beneficial to a non-clinical student sample.

Another intervention, the Mindful Self-compassion (MSC) programme, combines mindfulness and self-compassion exercises (Neff & Germer, 2013). The programme was designed for use in both clinical and healthy populations and, like the traditional mindfulness programmes, consists of 8 weekly sessions. Although the intervention addresses both mindfulness and self-compassion, MSC was designed primarily to increase self-compassion, but also focuses on teaching basic skills in mindfulness. MSC consists of a mixture of formal and informal exercises. Formal exercises include an affectionate breathing exercise, where participants are encouraged to bring affection and warmth to their breathing. Informal practices include bringing self-compassion to daily life, for example by putting hands gently on the heart during a stressful experience. Neff and Germer (2013) showed that community participants undergoing MSC reported larger gains in self-compassion, mindfulness and greater reductions in depression, anxiety, stress and avoidance than a waitlist control group. The intervention was also rated favourably by participants. This study demonstrates the potential of a mixed mindfulness and self-compassion intervention. This is important for two reasons. Firstly, self-compassion requires a certain level of mindfulness to begin with, in that participants do not get carried away or avoid negative thoughts or feelings (Neff, 2003a). Therefore mindful exercises may be a critical foundation for self-compassion exercises. In addition, although research has suggested that levels of self-compassion increase during mindful practice (Kuyken et al., 2010), there are no explicit exercises focusing on self-compassion. The intervention presented in the thesis will encompass mindfulness and self-compassion, as both were expected to, in slightly different ways, reduce the negative impact of appraisals of intrusive memories.



**Overview of the current research goal:**

In summary, the empirical work presented in this thesis begins by testing an intervention based specifically on research highlighting the role of reactions to intrusive memories in maintaining intrusion-related distress and depressive symptomatology. It is predicted that a short mindfulness and self-compassion based intervention will help individuals react to their memories less intensely, and therefore reduce both measures of subjective distress and depressive symptomatology. The second and predominant focus of the thesis is to extend upon research highlighting a role for individual differences in intrusive memory experience, using the Dual Mechanisms of Cognitive Control (DMC) framework. Research will initially be conducted in a non-valenced task, where chapter four will focus on a potential link between cognitive control and intrusive, negative memories, and chapter five will look at involuntary memory in the general sense. The final study, presented in chapter six, will extend this to emotional tasks of cognitive control. The research was conducted on student and community samples. The intervention study (chapter three) specifically recruited participants with current low mood, to ensure some degree of distress. However, no mood qualifier was used in the advertisements for the cognitive control studies. The use of a non-clinical university sample to test mindfulness and self-compassion based interventions is consistent with previous research (Neff & Germer, 2013; Smeets et al., 2014). The use of a non-clinical sample to address the question of underlying deficits in cognitive control is also consistent with the research introduced throughout this chapter (Verwoerd et al., 2009; Verwoerd et al., 2011; Wessel et al., 2008).

Importantly, these previous studies have found enough variation in both the intrusion experience and in cognitive control to find differences in cognitive control,

specifically proactive interference, within these samples. Furthermore, Brewin (1998) suggests that non-clinical populations are a good basis for examining intrusive memory experience. These samples can be used to establish the basic factors associated with memory experience, which can then later be applied to clinical samples. Consequently, the following empirical studies look to establish whether there is a link between intrusive and involuntary memories and individual differences in cognitive control. In addition, a novel intervention, designed specifically to reduce the impact of negative reactions to intrusive memories to will be examined. This work will now be presented.

## **Chapter two.**

### **General Methodology.**

In this chapter, the methodology used for the empirical work presented in the thesis will be introduced. The first section will outline the different ways of measuring intrusive and involuntary memories, and the second section will introduce the measures of depressive symptomatology, mindfulness and self-compassion. Research summarized in the introductory chapter suggests that research into intrusive memories should take more than a simple measure of memory frequency into account. Therefore, the studies presented will measure two elements of intrusive and involuntary memory experience; the frequency of the memory, and the consequences of the memory. These measures will now be introduced.

### **1) Frequency, via retrospective and diary measures:**

The clinical literature predominantly uses the Intrusive Memory Interview (Hackmann et al., 2004) to measure personally experienced intrusive memories. In this methodology, participants make retrospective assessments of the number of memories they have experienced over the past 7 days (Newby & Moulds, 2011a; Williams & Moulds, 2007c; Williams & Moulds, 2008b). Conversely, the involuntary memory literature primarily uses diary measures to study memory characteristics (Berntsen, 1998; Berntsen, 2001; Watson, Berntsen, Kuyken, & Watkins, 2013). Furthermore, when memory frequency is not the focus of the study, participants are often only asked to record first two involuntary memories they experience in a given day, until they have recorded a total of fifty memories. This is done as an attempt to reduce potential demand effects, for example artificially inflating the number of involuntary memories participants experience (Berntsen, 1998; Watson et al., 2012). Other times, involuntary memory studies use a two-structured approach where participants complete a small set of questions immediately after the memory, and a larger set of questions at a later time that suits them. This is done to reduce time

demands of the diary methodology and try to ensure, as far as possible, that participants comply with the task instructions (Berntsen, 2011).

There are advantages and limitations to the reliability of both retrospective and diary measures. For example, retrospective ratings may be distorted, especially in the presence of low mood (Beck, 1979) or stressful memories (Buchanan, 2007).

Additionally, Rasmussen, Johannessen, and Berntsen (2014) suggest that as involuntary memories are often experienced briefly and pertain to everyday events, retrospective assessments may easily underestimate the frequency of these memories.

However, as noted above, diary measures are also potentially inaccurate if participants do not comply with the instructions, for example because they had an involuntary memory at a time it was not convenient to record the details, or if they forgot to. Furthermore, Verwoerd et al. (2008) argue that the number of memories recorded in a diary may to some extent reflect an individual's ability to keep the goal of recording memories in mind, resulting in a higher number of memories being recorded by individuals high in attentional control. On the other hand, they also suggest that asking participants to keep a diary may artificially increase the number of intrusive memories experienced, because it may increase the activation of the memory. Their results support this second proposal; participants who kept a diary about their film-induced intrusive memories recorded three times as many as participants who retrospectively reported their memories. This finding has implications for the question of potential deficits in cognitive control. For example, Verwoerd et al. (2008) found that attentional control only predicted film-related intrusive memories in a group instructed to keep a diary of their intrusive memories. There was no relationship between participants who were asked to retrospectively

report on their intrusive memories. This suggests that keeping a diary did meaningfully impact frequency of the memories. To address this trade-off, and to ensure frequency estimates are as accurate as possible, the diary method will be used in all three investigations into cognitive control and intrusive/involuntary memory experience, specifically to assess frequency of negative involuntary memories (chapter four and six) and involuntary memories (chapter five). In addition, the retrospective measures of intrusive memories will be used to assess the frequency of intrusive memories in chapters four and six. Chapter five, which investigates a potential link between cognitive control and involuntary memory (regardless of the valence of the memory) will only use the diary methodology, as to my knowledge there are no validated retrospective measures of involuntary memories. In this study, however, given the possibility that participants will not fully comply with instructions to record all of their involuntary memories, they will be asked at the end of the procedure to estimate the number of memories they experienced, but did not write in the diary, for any reason. The properties of the measures used to index these aspects of intrusive and involuntary memories are summarized below.

*Intrusive Memory Interview* (IMI, Hackmann et al. (2004)):

The IMI will be used to measure the frequency of intrusive memories in chapters three, four and six. It is verbally administered and addresses participants' subjective experience of negative 'spontaneous' memories experienced over the past 7 days. Participants are given a definition of a spontaneous memory and are asked about the frequency of intrusions, along with content and sensory information concerning the memory. Participants rate various memory features on a scale of 0 (not at all) to 100 (very much), including distress, sense ofnowness, interference with daily activities.

Participants also rate the vantage perspective of the memory from -3 (completely first person) to +3 (completely third person). If participants experience intrusive memories about more than one event, subsequent questions are answered in relation to the most intrusive or most distressing of the memories.

*Diary of intrusive/involuntary memories:*

Diary measures will be used to assess both intrusive and involuntary memories in chapters four, five and six. The booklet consists of a small number of questions for each intrusive/involuntary memory they experience over a 7-day period, based on work by Berntsen and colleagues (Berntsen & Hall, 2004; Watson et al., 2012).

Participants were told this could include *any* intrusive or involuntary memory they experienced; it was not restricted to the memory talked about in the initial session.

Participants are asked to provide a short description of the memory, rate their current mood on a 5-point scale (0 very bad to 5 very good) and indicate whether the memory affected their mood (my mood became better/worse/uninfluenced). As an attempt to reduce demand effects as far as possible, participants are told not to worry if they do not experience any intrusive or involuntary memories over the week, and also that they should not feel obliged to record any details they did not want to. In addition, for the involuntary memory study (chapter five) participants will be asked to rate the valence of the memory on a scale from 0-5 (0 representing an extremely negative memory, 5 representing an extremely positive memory). See Appendix A for examples of an intrusive/involuntary memory diary page.

*Compliance questionnaire:*

This measure will be used in the involuntary memory study (chapter five). After handing in their diaries, participants are given a questionnaire which asked them to estimate the number of times they experienced a memory that they could not put into words, the number of times they experienced a memory when it was impractical to record details of the memory and the number of memories they did not report for any other reason. No other detail of the memory was asked, therefore this measure allows



participants to include memories they did not want to disclose any specific details about. The total number of memories indicated on this questionnaire was added to the number of memories recorded in the diary to form a summative measure of involuntary memories. See Appendix B.

## **2) Consequence measures:**

*Impact of Event Scale* (IES; Horowitz et al. (1979)):

The IES will be used to measure the consequences of intrusive memories in chapters three, four and six. The IES assesses the subjective impact of a specific life event and has two subscales, measuring intrusiveness and avoidance respectively. The intrusion subscale indexes the frequency and variety of intrusions associated with the specific event (e.g. ‘pictures about it popped into my mind’, ‘other things kept making me think about it’), and the avoidance subscale assesses attempts to suppress thoughts and memories associated with the event (‘I tried not to talk about it’, ‘I avoided letting myself get upset when I thought about it or was reminded of it’). Each item is rated on a four-point scale; not at all (scored as 0), rarely (scored as 1), sometimes (scored as 3) or often (scored as 5). Scores are calculated for the intrusion and avoidance subscales separately, and then an overall total (maximum 70) is calculated. As done in previous research, if participants report having experienced more than one intrusive memory over the past week, the IES is filled out in regards to the memory the participant identifies as the “most intrusive or most distressing”. Higher scores reflect greater levels of intrusiveness and avoidance. Internal consistencies of the intrusion subscale has been reported as .78 and the avoidance subscale as .82 (Horowitz et al., 1979).

*Ruminative Response Scale* (RRS, subscale of the Response Style Questionnaire Treynor et al. (2003)):

The RRS will be used in chapters four, five and six as a consequence measure. It consists of 22 items which participants are instructed to respond to in respect to how much they think about or engage in the items when they feel down or depressed (e.g. ‘think about how passive and unmotivated you feel’ and ‘think ‘why do I always react this way?’’). Each item is rated on a four-point scale from 1 (almost never) to 4 (almost always) and scores are summed across all items. The RRS has a good internal consistency of .90 (Nolen-Hoeksema, Parker, & Larson, 1994).

### **3) Additional measures used in the thesis:**

*Beck Depression Inventory- Second edition* (BDI-II; Beck et al., 1996):

The BDI-II will be used as a measure of depressive symptomatology in all four studies. It is one of the most common ways of measuring depressive symptomatology, in both clinical and research settings. Participants are asked to rate their experience of 21 cognitive, affective and behavioural features of depression. Items include a loss of pleasure, changes in appetite and concentration difficulties and are measured on a 3 point scale, ranging from no endorsement of the symptom (e.g. I get as much pleasure as I ever did from the things I enjoy’) to a high endorsement of the symptom (‘I can’t get any pleasure from the things I used to enjoy’). Participants are instructed to respond in terms of how they have been feeling over the past two weeks. The maximum score is 63, and higher scores reflected a higher experience of depressive symptomatology. The internal consistency of the BDI-II in a student sample has been reported as .90 (Storch, Roberti, & Roth, 2004).

*Mindful Attention and Awareness Scale* (MAAS; Brown and Ryan (2003)):

The MAAS will be used in chapter three and is a 15-item scale assessing mindfulness in common everyday experiences. Participants are asked to respond in terms of what ‘really reflects’ their experiences, as opposed to what they think their experiences should be. Example statements include ‘I rush through activities without being really attentive to them’ and ‘I snack without being aware that I’m eating’. Each item is rated on a scale of 1-6 (1 representing almost always, 6 representing almost never) and a mean score is calculated. Higher overall scores represent a greater level of trait mindfulness. Internal consistency of the MAAS has been reported as .82 in a general student sample (Brown & Ryan, 2003).

*Self-compassion Scale* (SCS; Neff (2003b)):

The SCS will also be used in chapter three. It is a 26-item self-report which assesses the extent to which individuals show themselves compassion in times of difficulty. The SCS has six subscales; self-kindness (e.g. ‘I try to be loving to myself when I am in emotional pain’), mindfulness (e.g. ‘When I fail at something important to me I try to keep things in perspective’), common humanity (e.g. ‘I try to see my failings as part of the human condition’), self-judgment (e.g. ‘I’m disapproving and judgmental about my own flaws and inadequacies’), over-identification (e.g. ‘when I’m feeling down I tend to obsess and fixate on everything that’s wrong’) and isolation (e.g. ‘when I’m feeling down, I tend to feel like most people are probably happier than I am’). Items are scored on a scale of 1 (almost never) to 5 (almost always). Scores for negative items are reverse scored, and a mean score is calculated. The SCS has been demonstrated to have an internal consistency of .92 (Neff, 2003b).

## **Chapter three.**

**An investigation into mindfulness  
and self-compassion training to  
reduce the impact of intrusive  
memories.**

## **Introduction:**

This chapter will explore the efficacy of a mindfulness and self-compassion intervention to reduce the distress arising from the experience of intrusive memories in a low mood sample. As discussed in the introductory chapter, an abundance of research emphasizes that it is not necessarily the intrusive memory per se that causes high levels of distress in individuals vulnerable to depression, but instead the way people vulnerable to low mood appraise their memories (Starr & Moulds, 2006; Williams & Moulds, 2008b). Reactions such as ‘something is wrong with me and ‘I cannot cope’ have been shown to increase levels of distress and maintain symptoms of depression over time (Williams & Moulds, 2008b). The current study therefore investigates the efficacy of a mixed mindfulness and self-compassion intervention to reduce this emotional reactivity. Empirical evidence to support mindfulness and self-compassion based interventions to support this research goal will be reviewed, before the current study is described.

The model of PTSD maintenance by Ehlers and Steil (1995) provides the rationale for the current study. The model emphasizes the importance of the appraisals ascribed to the memory, both in terms of the memory content (‘it was my fault’) and the consequences of experiencing an intrusive memory (‘there is something wrong with me’). According to the model, assigning a negative appraisal to a memory increases the distress experienced with the memory, which then in turn may encourage more avoidance behaviours (e.g. thought suppression). However, these avoidance behaviours contribute to the persistence of the intrusive memories by preventing a change in the meaning of the event and preventing the memory from being successfully emotionally processed (Rachman, 1980). As such, the distress associated

with the memory has been shown to be more important than the frequency of the memory in determining mental well-being. The Ehlers and Steil (1995) model has since been extended to apply to the non-traumatic intrusive memories experienced by individuals with depression, both in correlational (Starr & Moulds, 2006; Williams & Moulds, 2008b) and causal (Lang et al., 2009) data. For example, in a student sample, Williams and Moulds (2008a) found that intrusion-related distress (rated on a 100-point scale) was significantly positively correlated with BDI-II scores, and BDI-II scores correlated with Impact of Event Scale (IES) scores (both the intrusiveness and avoidance subscales), irrespective of the frequency of the intrusive memory. Assigning a negative meaning to intrusions was also associated with higher intrusion-related distress and BDI-II scores, as well as higher engagement in avoidance behaviours, specifically suppression and rumination. To my knowledge, the study presented in this chapter is the first to directly test the prediction that reducing the impact of appraisals would reduce depressive symptomatology, as predicted by Brewin (1998). Lang et al. (2009) did use Cognitive Bias Modification (CBM) to look at the impact of appraisals on intrusion experience. They induced either positive or negative appraisals about intrusive memories (e.g. having an intrusive memories means nothing/something is wrong with me) in student participants and measured the number of intrusions over the next week (indexed through diary recordings) after watching a sad film. Participants in the negative appraisal condition recorded more intrusions in their diaries, and reported higher IES scores than participants in the positive appraisal condition. These results suggest a causal impact of appraisals on intrusion development, beyond correlational data. This supports the current objective of changing the way people react to their intrusive memories and suggests that

reducing the impact of appraisals would have a beneficial impact on both intrusive memory distress and mood.

Rumination, the passive focus on the causes and consequences of symptoms of depression (e.g. ‘think about how sad I feel’ (Treynor et al., 2003)) has also been demonstrated to exacerbate negative reactions to intrusive memories (Williams & Moulds, 2010). Although rumination has been implicated in the onset and maintenance of depression (Nolen-Hoeksema, 2000; Watkins, Moberly, & Moulds, 2008), it has since been demonstrated that it is not specifically the self-focus aspect of rumination that is detrimental to mood. Instead, it is the analytical processing style that accompanies ruminative processing that is problematic, for example focusing on *why* I feel this way (Watkins, 2004; Watkins & Teasdale, 2004). However, an experiential self-focus, for example focusing on *how* I feel, can be advantageous to mood, and facilitate adaptive emotional processing (Teasdale, 1999). This distinction between analytical and experiential self-focus forms the basis of mindful practice, which will now be discussed. The rationale for using a mindfulness intervention to reduce the impact of negative appraisals will then be introduced. Mindfulness involves a non-judgemental focus of attention on thoughts and sensation being experienced in the present moment (Kabat-Zinn, 1994). During mindful practice, participants are taught to just notice what comes to mind, without judging or trying to change their experience, for example through avoidance or suppression. Exercises in the mindfulness programme include the body scan, where attention is progressively directed to different parts of the body, for example the knees and the toes, and the sitting meditation, where attention is directed to the breath. These provide a focal point to help participants start to notice when their attention wanders, and help

improve their ability to bring their attention back to the exercise once they are aware that their attention has wandered. Mindfulness-based interventions (MBIs) exist in various forms, including Mindful-based Stress Reduction (MBSR), Mindfulness-based Cognitive Therapy (MBCT), which both last eight weeks, and shorter interventions. MBCT was specifically designed for individuals experiencing recurrent episodes of clinical depression and is founded on the idea that it is not the initial experience of low mood that provokes relapse into an episode of depression. Instead, it is the negative thinking patterns activated during a period of low mood that can propel the downward ruminative cycle into long-term low mood or depression (Segal, Williams, & Teasdale, 2002; Teasdale et al., 1995). Therefore, as discussed in the introduction, MBCT specifically targets these patterns of negative thinking. The programme teaches participants to become more aware of these ruminative patterns and disengage from them before they lead to longer episodes of low mood. It has been demonstrated that MBCT is selectively effective in reducing depressive relapse in individuals with 3 or more previous episodes of depression, and is not effective in reducing relapse in individuals with one or two previous episodes (Ma & Teasdale, 2004; Teasdale et al., 2000). Furthermore, Ma and Teasdale (2004) demonstrated that this selective effect on individuals who with three or more previous episodes reflected differences in the underlying cause for relapse; MBCT was most effective in reducing relapse when the relapse was not preceded by a major life event, when it presumably, therefore, was instead triggered by internal ruminative processes. This selective effect has been taken as evidence of the impact on MBCT in reducing ruminative processes. Other more general mindful-based interventions, have been found to be effective in wider populations than the selective effects of MBCT on individuals with three or more episodes of depression, including healthy individuals (Khoury, Sharma, Rush, &



Fournier, 2015), medical students (Rosenzweig, Reibel, Greeson, Brainard, & Hojat, 2003) and inner-city populations (Smith, Metzker, Waite, & Gerrity, 2015).

Interventions that last less time than the traditional eight-week programmes have also been shown to be effective. This is an important extension of existing interventions, given the substantial time commitments of the traditional programmes and the problem of attrition (Crane & Williams, 2010; Tappen, 2014). Cavanagh et al. (2013) reported improvements in stress, anxiety and depression in a large student sample following a two-week online mindfulness training course, consisting of short-recorded exercises. These studies are evidence that mindfulness interventions, in various forms, are beneficial beyond the selective impact of MBCT on participants with three or more episodes of depression. This in turn supports the extension of mindfulness training to reduce intrusive-memory distress in a low mood student sample. Research looking at *how* mindfulness works also supports the proposed intervention. Heeren and Philippot (2011) found that the benefits of mindfulness on symptoms of stress, depression and anxiety were mediated by changes in rumination in a general sample. This is evidence that rumination is one aspect that changes through training, and suggests that mindfulness training could reduce negative emotional reactivity that has been shown to occur after an intrusive memory (Moulds et al., 2008; Starr & Moulds, 2006; Williams & Moulds, 2008b). This potential leads to the question of whether any reduction would consequently be accompanied by a decrease in depressive symptomatology. Engaging in mindful practice encourages participants not to suppress their memory, as well as not to get caught up in negative thinking about the memory. Instead, they are encouraged to let the memory pass out of awareness again, without reacting to it in a ruminative way or engaging in any negative appraisals. As it has specifically been shown that ruminative processing exacerbates negative

responses to intrusive memories (Williams & Moulds, 2010), an intervention to reduce this detrimental reaction is important.

Self-compassion is a closely related concept to mindfulness that is also predicted to help counteract the self-condemnatory reactions accompanied by an intrusive memory (i.e. 'there is something wrong with me', Newby and Moulds (2010)). Neff (2003a) defines self-compassion as 'generating the desire to alleviate one's suffering and heal oneself with kindness' (p.87). While we are often compassionate towards others, we typically do not extend this kindness to ourselves when faced with difficult personal circumstances (Neff, 2003a). In addition, self-attitudes in people with mood disorders are known to be negative and self-deprecating (Van Dam, Sheppard, Forsyth, & Earleywine, 2011). Furthermore, individuals have also been shown to react in a non self-compassionate way to intrusive memories, for example 'because I can't control this memory, I am a weak person' (Moulds et al., 2008). Research has indicated that higher levels of trait self-compassion are associated with lower levels of anxiety and depression (Neff, 2003b) and higher levels of happiness and positive affect (Neff et al., 2007). It has also been shown that self-compassion can reduce reactions to potentially upsetting events, such as writing about personal weaknesses (Neff et al., 2007), when receiving ambivalent feedback and imagining upsetting social events, which included losing an important game for their sports team or forgetting their lines during a stage performance (Leary et al., 2007). Higher self-compassion has also been associated with better adaption to university life in first year students (Terry et al., 2013), specifically reflected by lower levels of depression and lower levels of homesickness.

As discussed in the introduction chapter, various self-compassion based interventions have been empirically tested, with some promising results. For example, Compassionate Mind Training (CMT) was developed for people with high levels of shame and self-criticism and is designed to help individuals to change the way in which they relate to themselves (Gilbert & Irons, 2005). One exercise in CMT is the generation of compassionate imagery. Participants are encouraged to create and explore feelings they associate with a compassionate being, real or imaginary, and to apply this compassionate focus to their specific difficulty. Another important part of the CMT programme is writing a compassionate letter to the self from the perspective of the chosen compassionate image, to facilitate adapting to a more compassionate self-to-self relating. These components of CMT will be incorporated into the current intervention. The aim is to encourage individuals to react more compassionately to the distress they may feel about their intrusive memory. Gilbert and Procter (2006) reported significant reductions in depression, anxiety and shame in a small study of CMT, consisting of twelve two-hour sessions, in patients (mean age = 45.2 years, SD = 5.54) attending a day centre for a variety of psychological issues. They did not include a control group. Neff and Germer (2013) designed a Mindful Self-Compassion program for clinical and non-clinical populations. The intervention lasts eight weeks, and includes exercises in affectionate breathing, finding a compassionate voice and managing difficult emotions by learning to better read the body and react appropriately (for example, noticing tension). Compared to a waitlist control group, MSC participants reported significant increases in self-compassion, mindfulness and life satisfaction, and decreases in depression, anxiety, stress and emotional avoidance (Neff & Germer, 2013). Smeets et al. (2014) tested a shorter self-compassion intervention in female college students. Participants took part in two sessions, where

they completed exercises to promote self-compassion. These exercises included being encouraged to be self-compassionate in response to negative events and to practice compassionate statements daily (e.g. ‘may you be kind to yourself’). Compared to a waitlist control group, participants in the compassion group reported increases in self-reported mindfulness, self-compassion, self-efficacy and optimism, and also decreases in rumination. This study suggests that a self-compassionate intervention can enhance well-being in a non-clinical student sample, such as the one tested in the current chapter.

Three main reasons support the investigation of a *mixed* mindfulness and self-compassion intervention. Firstly, both mindfulness and self-compassion are predicted to reduce intrusive-memory distress; mindfulness by reducing emotional reactivity, for example ‘having this memory means I am losing my mind’ (Moulds et al., 2008) and self-compassion by encouraging participants not to be as self-deprecating about the memory, for example ‘this memory means I am weird or abnormal’ (Moulds et al., 2008). Secondly, Neff (2003a) suggests that in order to be self-compassionate, individuals need to be able to hold negative emotions in check (i.e. not avoid or get carried away with them), therefore mindful practice is an important foundation to self-compassion exercises. Thirdly, the enhancement of self-compassion that may arise through mindfulness training is only implicit; there are no exercises during mindfulness training that directly encourage a self-compassionate attitude. However given the predicted benefits of self-compassion to reduce the impact of negative reactions to intrusive memories, making this an explicit component of the intervention is predicted to provide additional benefit to participants. No previous research has

directly tested the effect of either mindfulness or self-compassion training on intrusive memory experience.

### **The present study:**

The present study will test the effectiveness of a brief three-week group intervention (consisting of two mindfulness sessions and one self-compassion session) in reducing intrusive memory related-distress, in individuals currently experiencing intrusive memories and low mood. Participants will be measured on the Impact of Event Scale (IES, including separate analysis of the intrusiveness and avoidance subscales), Beck Depression Inventory II (BDI-II), Mindful Attention and Awareness Scale (MAAS) and the Self-Compassion Scale (SCS) both pre-intervention (time 1) and one week post-intervention (time 2). Changes on these self-report questionnaires will be compared to a group taking part in three weeks of relaxation sessions. Using relaxation as a control group controls for placebo or demand effects (Baer, 2003) as well as non-specific treatment effects (e.g. group support, contact with researchers, completing questionnaires) of the intervention. Specifically, the relaxation exercises are conducted in group sessions which follow a similar format to the mindfulness/self-compassion sessions, and participants are presented with a similar rationale at the beginning of the intervention. However an important difference between the two interventions is that during relaxation exercises there is a specific intention to relax, which is opposed to mindful practice, which is approached with a non-striving attitude. There is also no emphasis on the importance of a non-judgemental attitude in relaxation exercises, which is a core component of mindfulness. Relaxation-based interventions have previously been shown to reduce depressive symptomatology (Jain et al., 2007; Jorm, Morgan, & Hetrick, 2008). However in a comparison of a one-

month mindfulness to a one-month relaxation intervention, Jain et al. (2007) demonstrated that only the mindfulness group showed a reduction in rumination, while both groups showed a positive change in distress and positive state of mind, as compared to a waitlist control. This suggests that while both processes may result in a decrease in depressive symptomatology, the benefits of relaxation are more general than the predicted specific impact of mindfulness on ruminative processes, and that therefore the mindfulness/self-compassion will be more beneficial at reducing intrusion distress.

Consistent with all four studies presented in the thesis, the correlations between the self-report measures will be examined to further enhance our understanding of intrusive memory experience and to form a clear picture of the sample being tested. No existing research has looked at the relationships between intrusive memory experience, mindfulness and self-compassion. For the baseline measures, the questionnaire will be collapsed across intervention group. The correlations between change scores in mindfulness and self-compassion and changes on the other self-report measures (IES, BDI-II and RRS) will also be looked at to determine the way in which the intervention is successful. This analysis will be done separately for the two groups.

## **Predictions:**

### **1) Baseline data:**

In light of existing research citing mindfulness and self-compassion as adaptive for psychological well-being, higher levels of mindfulness (measured by the MAAS, Brown and Ryan (2003)) and self-compassion (measured by the SCS, Neff (2003b))

are predicted to negatively correlate with depressive symptomatology (as measured by the BDI-II, Beck et al. (1996)). No previous research has looked at mindfulness and self-compassion in relation to intrusive memory experience, therefore it is unclear whether IES scores will correlate with the MAAS and SCS scores.

## **2) Group differences following training:**

Reductions in depressive symptomatology have been demonstrated after both mindfulness/self-compassion (Cavanagh et al., 2013; Jain et al., 2007; Neff & Germer, 2013) and relaxation training (Jain et al., 2007; Jorm et al., 2008), therefore a main effect of time on BDI-II is expected in both groups. However, as the changes in the mindfulness/self-compassion training is expected to come about specifically through a reduction in rumination (Heeren & Philippot, 2011; Smeets et al., 2014) and given the impact of ruminative appraisals on maintenance of low mood (Newby & Moulds, 2011c; Williams & Moulds, 2008b), it is predicted that participants in the mindfulness and self-compassion group will report greater reductions on the IES and on the BDI-II between time 1 and time 2 than participants in the relaxation group. It is also predicted that only the mindfulness/self-compassion group will show significant positive changes on the measures of mindfulness and self-compassion, as the relaxation training will not incorporate these concepts.

## **3) The relationship between changes in mindfulness and self-compassion, and changes on the IES and BDI-II:**

In light of the close relationship between mindfulness and self-compassion (Birnie, Speca, & Carlson, 2010; Neff, 2003a; Smeets et al., 2014), a significant positive correlation between increases in mindfulness and increases in self-compassion is

expected. Additionally, as the benefits of mindfulness and self-compassion on intrusive memory experience are hypothesised to come from specific aspects of mindfulness and self-compassion, there is predicted to be a significant positive correlation between changes on the MAAS and SCS, and changes on the IES, in the mindfulness/self-compassion group only. No such correlation is expected in the relaxation group. There is also predicted to be a significant negative correlation between changes on the MAAS/SCS and BDI-II in the mindfulness/self-compassion group. Again, no such correlation is expected in the relaxation group, because these concepts are not addressed in relaxation training.

## **Methods:**

### *Participants:*

The study was granted ethical approval from the University Teaching and Research Ethics Committee (UTREC). Participants were all students from the University of St Andrews, recruited via noticeboards in the department and through the University weekly memo system. Participants volunteered on the basis of having recently experienced intrusive memories with concurrent low mood. In total, 21 participants responded to an advert to participate in a study about mindfulness, self-compassion and intrusive memories and 20 participants responded to an advert to participate in a study about relaxation and intrusive memories. Therefore, it is important to note that participants self-selected for the type of intervention they participated in, a limitation that will be addressed in the discussion. Three participants withdrew from the mindfulness and self-compassion condition and two withdrew from the relaxation condition. Data were only analysed for those participants who completed the study. As a result, the final sample consisted of 19 participants for the mindfulness and self-



compassion condition (15 female, 4 male) and 18 participants for the relaxation condition (16 female, 2 male). Distribution of the questionnaire data was checked by ensuring all questionnaire data fell within 3 SDs of the mean. No data were consequently excluded. Power analysis revealed that a total sample size of 36 would be required to detect a medium effect size at a 95% confidence interval using the .05 criterion of statistical significance. Therefore the sample size was sufficient.

Participants received either £10 or a book for their participation.

### **Training:**

#### *Mindfulness and self-compassion sessions:*

The mindfulness and self-compassion training took part in groups of 3-5 participants per group, and consisted of 3 weekly sessions. The first session began with a short overview of the benefits of mindfulness on mental well-being before introducing participants to the concept of mindfulness by talking about *mindlessness* and highlighting occasions where we rush through activities or get carried away worrying about the future etc. Participants were next taken through the raisin exercise. This exercise encourages participants to really pay attention to the process of eating a raisin, in order to emphasize how mindlessly we sometimes eat. After this and each subsequent exercise in the training procedure, participants were encouraged to take part in a group discussion about their experiences. During this first session, participants were also guided through a sitting meditation, where participants are encouraged to focus on their breath and bring their attention back to the breath should their mind wander. Over the coming week, participants were encouraged to bring mindfulness to an everyday activity (e.g. walking to class or washing the dishes) and were emailed an mp3 copy of the sitting meditation to practice at home once a day (or as often as they were comfortable doing so). The second session began with another

sitting meditation, and then introduced the 3-minute breathing space. This is a shorter mediation exercise, which participants are encouraged to turn to when they feel they are not being mindful, and helps to bring them back to a mindful focus. Participants were then given some red dot stickers to place in locations of their choice (e.g. on a bedroom mirror or a laptop) to serve as a reminder to be mindful throughout their daily lives. During the third week, participants took part in the self-compassion based exercises. The format of the session was adapted from Compassionate Mind Training (CMT) designed by Gilbert and Procter (2006) and outlined in Gilbert (2009), as well as the MSC program designed by Neff and Germer (2013). The first exercise involved generating a personalized compassionate image that participants could work with during the session, with qualities including wisdom, strength, warmth and non-judgmental acceptance. Participants were encouraged to think about images and feelings that arise when thinking of compassion they have for somebody else (e.g. a family member or a friend) to help them generate their compassionate images. The next task involved writing a letter from their compassionate self about the way they feel when they experience an intrusive memory. The final exercise involved creating five compassionate statements to the self to be practiced over the next week (e.g. ‘I would be sympathetic towards a friend in my situation. I’d like to feel this way about myself’). Over the next week participants were instructed to spend approximately one minute visualizing their kind, accepting image and to read the statements with warmth while holding their compassionate image in mind. As another homework element, participants were encouraged to try and generate their compassionate image when faced with their intrusive memories.

### *Relaxation sessions:*

The relaxation sessions were also run in groups of 3-5 participants, and consisted of three weekly sessions. The first session began with a similar short overview about the benefits of relaxation on mental well-being. Participants were then guided through a deep breathing exercise and, as in the mindfulness/self-compassion condition, participants were encouraged to discuss their experiences in the group after each exercise they took part in. Also during the first session, participants were guided through a progressive muscle relaxation, an mp3 copy of which was emailed to them to practice at home once a day, or as often as they felt comfortable with. The second session began with another progressive muscle relaxation and then introduced a guided imagery exercise, followed by further group discussions. Participants were encouraged to practice the guided imagery over the next week, once or a day or as much as they felt comfortable with. In the third session participants again completed the progressive muscle relaxation introduced in session one and then took part in a second more extensive deep breathing exercise. Participants were encouraged to continue to practice relaxation exercises over the next week and also to try and practice the exercises when they experienced an intrusive memory.

### *Procedure:*

Participants first came into the research lab for an individual interview session where they provided informed consent and were taken through the Intrusive Memory Interview to determine the presence of intrusive memories experienced over the past week (time 1). Participants then completed the battery of self-report questionnaires detailed above (IES, BDI-II, MAAS and SCS) in a randomized order. The three-week training in either mindfulness and self-compassion or relaxation followed. One week

after the final session, participants returned to the research lab for a final time (time 2) to recomplete the self-report questionnaires, to be debriefed and to be compensated for their time.

## **Results:**

### **1) Baseline data:**

In conjunction with previous research (Brewin et al., 1996, Newby & Moulds, 2012), the intrusive memories that participants reported included relationship/family problems (e.g. when my girlfriend broke up with me, an argument with my friend at a University ball), work/school issues or personal failure (e.g. disagreement with a supervisor at work, an embarrassing job interview) and illness/death of another (e.g. being with Mum as she died in the hospital, receiving the news that a school teacher had died in a car accident) . The mean rating of intrusive memory distress in mindfulness/self-compassion group was 66.32 (SD = 19.85) out of 100, and the mean rating of distress in relaxation group was 65.23 (SD = 20.25) out of 100. An independent samples t-test revealed that this difference was not significant,  $t(35) = .16$ ,  $p > .05$ . Distress ratings were similar between the two groups.

### **i) Group differences pre-training:**

All questionnaire data fell within 3 SDs of the mean; therefore no data was excluded from analysis. There were no between-group differences on any of the measures at time 1. These results are displayed in Table 3.1 below. Levene's test for Equality of Variances was non-significant for all measures apart from the SCS,  $F(1, 35) = 4.81$ ,  $p < .05$ . Therefore a t-test not assuming homogeneity of variances was computed for the

SCS measure. There was however still no significant difference in SCS scores between the two groups at baseline.

Table 3.1

*Descriptive statistics (means and standard deviations) at time 1 and t-tests comparing group characteristics at time 1.*

Measure	Relaxation: Mean (SD)	Mindfulness/Self-Compassion: Mean (SD)	t-value	sig.
	N = 18	N = 19		
<b>IES</b>	42.61 (14.59)	43.42 (12.07)	-0.18	n.s.
<b>IES - intrusive</b>	19.11 (7.68)	22.58 (7.07)	-1.43	n.s.
<b>IES – avoidance</b>	23.50 (8.66)	20.84 (6.37)	1.07	n.s.
<b>BDI-II</b>	20.44 (14.85)	19.37 (11.13)	0.25	n.s.
<b>SCS</b>	2.71 (.93)	2.52 (0.68)	0.72	n.s.
<b>MAAS</b>	3.58 (.73)	3.18 (0.97)	1.42	n.s.

## ii) Correlations between the measures at time 1:

Table 3.2 overleaf is a correlation matrix displaying the relationships between the measures at baseline, collapsed across training group. As predicted, both the measures of mindfulness and self-compassion were negatively correlated with BDI-II scores. Also as predicted, individuals reporting higher levels of mindfulness also reported higher self-compassion. In terms of intrusive memory experience, there was no significant correlation between overall IES score and mindfulness. However, looking at the subscales of the IES, higher levels of mindfulness were associated with less memory ‘intrusiveness’, although mindfulness was not related to memory ‘avoidance’. Higher self-compassion, conversely, was related to lower overall IES scores, and again higher self-compassion was related to lower levels of ‘intrusiveness’ but was not significantly related to avoidance.

Table 3.2

*A correlation matrix displaying correlations between the self-report measures at baseline.*

	Measure	1. IES	2. IES-I	3. IES-A	4. BDI-II	5. MAAS	6. SCS
1	IES						
2	IES - intrusiveness	.87 **					
3	IES - avoidance	.88 **	.53 **				
4	BDI-II	.35 *	.31	.30			
5	MAAS	-.32	-.37 *	-.18	.64 *		
6	SCS	-.35 *	-.35*	-.27	.81 **	.63 **	

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$ , two-tailed.

## 2) Post-intervention data:

### i) Group differences following training:

To compare the effects of the intervention, a 2 (within-subjects factor: time 1, time 2) x 2 (between-subjects factor: relaxation group, mindfulness/self-compassion group) repeated-measures ANOVA was conducted for each of the self-report measures to compare the effects of the interventions.

*a) Impact of Event Scale (IES):*

*Overall IES scores:*

There was a main effect of time on IES scores,  $F(1, 35) = 19.42$ ,  $p = .01$  partial  $\eta^2 = .36$ . IES scores were lower at time 2 (mean = 33.30, SD = 2.12) than time 1 (mean = 43.02, SD = 2.20). The time x group interaction was not significant,  $F(1, 35) = 2.36$ ,  $p > .05$ . IES scores at time 1 and time 2 are displayed in Figure 3.1 below.

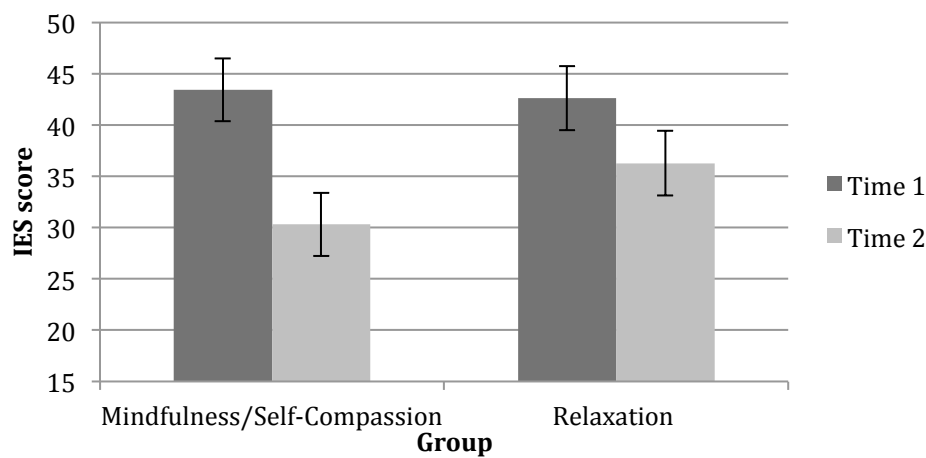


Figure 3.1. IES scores at time 1 and time 2, split by intervention group.

*Intrusiveness subscale:*

There was a main effect of time on the intrusiveness subscale,  $F(1, 35) = 17.36$ ,  $p = .01$ , partial  $\eta^2 = .33$ . Intrusiveness scores were lower at time 2 (mean = 14.64, SD = 1.36) than at time 1 (mean = 17.14, SD = 1.50). The time x group interaction however was not significant,  $F(1, 35) = 2.31$ ,  $p > .05$ . The IES intrusiveness scores at time 1

and time 2 are displayed in Figure 3.2 below.

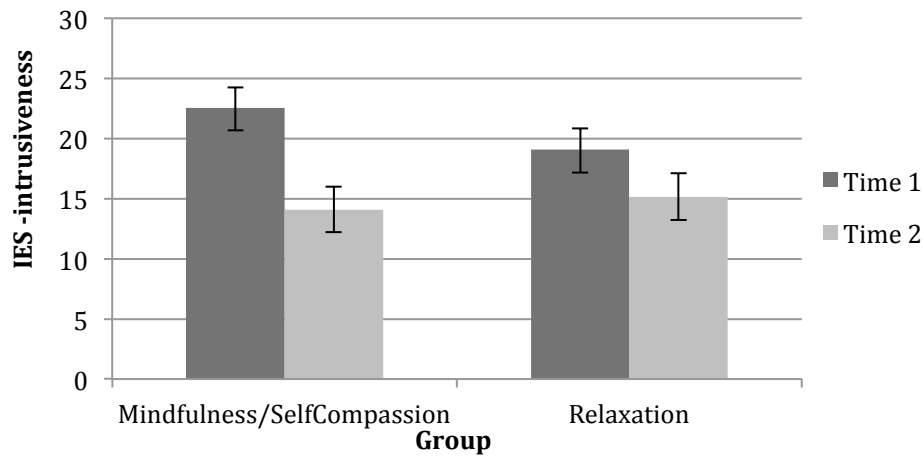


Figure 3.2. IES intrusiveness scores at time 1 and time 2, split by intervention group.

#### *Avoidance subscale:*

There was a main effect of time on the avoidance subscale,  $F(1, 35) = 9.33$ ,  $p = .01$ , partial  $\eta^2 = .21$ . Avoidance scores were lower at time 2 (mean = 18.55, SD = 1.32) than at time 1 (mean = 22.17, SD = 1.25). The time x group interaction was not significant,  $F(1, 35) = .73$ ,  $p > .05$ . The IES avoidance scores at time 1 and time 2 are displayed in Figure 3.3 below.

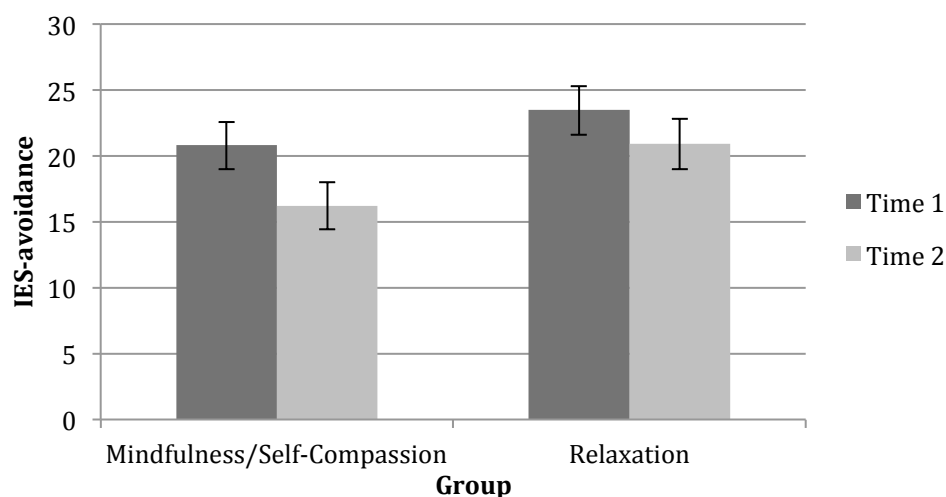


Figure 3.3. IES avoidance scores at time 1 and time 2, split by intervention group.



*b) BDI-II:*

There was a main effect of time on the BDI-II,  $F(1, 35) = 30.42$ ,  $p = .01$ , partial  $\eta^2 = .47$ . BDI-II scores were lower at time 2 (mean = 13.75, SD = 1.82) than at time 1 (mean = 19.91, SD = 1.82). The time x group interaction was also significant,  $F(1, 35) = 8.58$ ,  $p = .01$ , partial  $\eta^2 = .20$ . Post hoc comparisons (Bonferroni corrected) revealed that the reduction in BDI-II scores between time 1 and time 2 was significant for the mindfulness/self-compassion group (change 9.42),  $t(18) = 5.01$ ,  $p = .01$  and only just reached significance in the relaxation group (change 2.88),  $t(17) = 2.52$ ,  $p = .02$ . This is displayed in Figure 3.4.

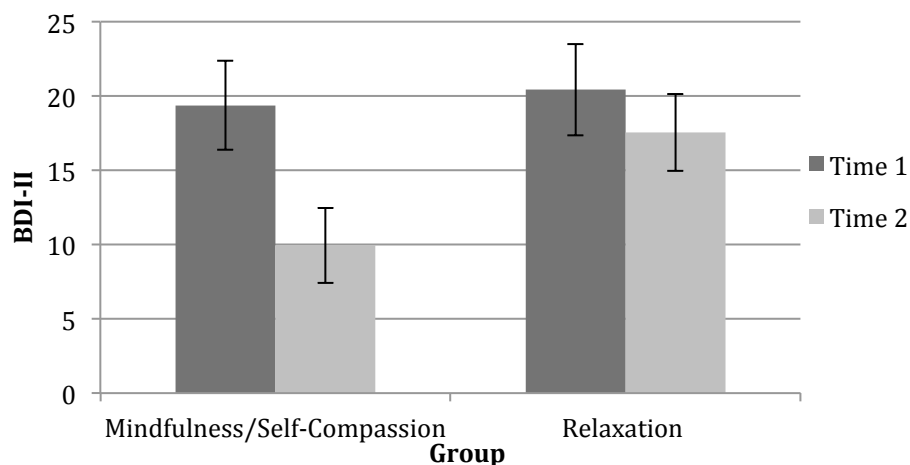


Figure 3.4. BDI-II scores at time 1 and time 2, split by intervention group.

*c) MAAS:*

There was a main effect of time on the MAAS,  $F(1, 35) = 8.48$ ,  $p = .01$ , partial  $\eta^2 = .20$ . Participants reported higher levels of mindfulness at time 2 (mean = 3.74, SD = .12) than at time 1 (mean = 3.38, SD = .14). The time x group interaction was also significant  $F(1, 35) = 7.45$ ,  $p = .01$ , partial  $\eta^2 = .18$ . Paired samples t-tests (Bonferroni corrected) revealed this reflected a significant increase in MAAS scores in the mindfulness/self-compassion group,  $t(18) = -3.18$ ,  $p = .01$  between time 1 and time 2,

but not a significant increase in MAAS scores in the relaxation group,  $t(17) = -.22$ ,  $p > .05$  between these periods. This is displayed in Figure 3.5 below.

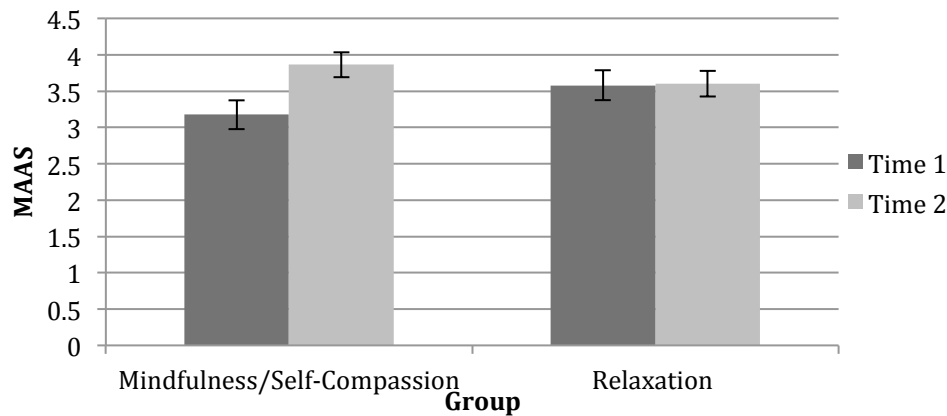


Figure 3.5. MAAS scores at time 1 and time 2, split by intervention group.

*d) Self-Compassion Scale (SCS):*

There was a main effect of time on SCS scores,  $F(1, 35) = 11.17$ ,  $p = .01$ , partial  $\eta^2 = .24$ . Participants reported being more self-compassionate at time 2 (mean = 2.91, SD = .13) than at time 1 (mean = 2.61, SD = .13). The time x group interaction was significant  $F(1, 35) = 5.85$ ,  $p = .02$ , partial  $\eta^2 = .14$ . Paired-sample t-tests (Bonferroni corrected) revealed this reflected a significant increase in SCS scores in the mindfulness/self-compassion group,  $t(18) = -3.61$ ,  $p = .01$  between time 1 and time 2, but no significant increase in SCS scores in the relaxation group,  $t(17) = -.79$ ,  $p > .05$  between these times. This is displayed in Figure 3.6 overleaf.

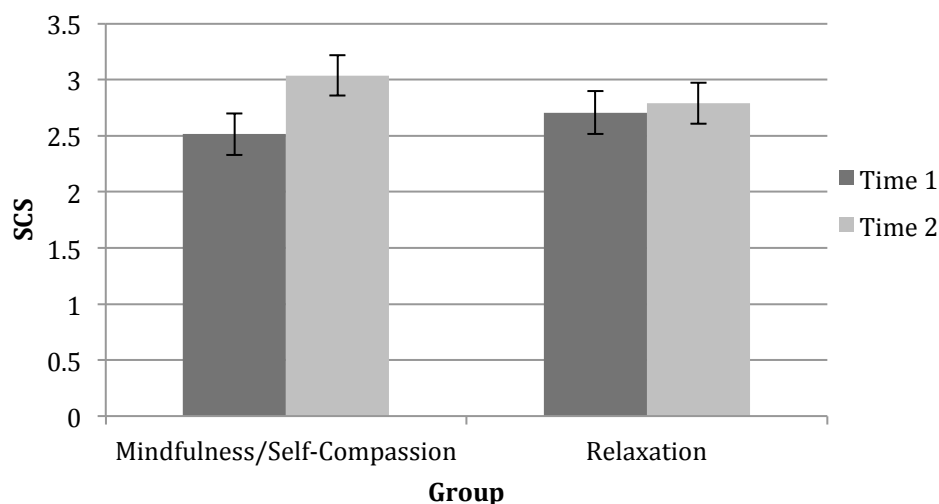


Figure 3.6. SCS scores at time 1 and time 2, split by intervention group.

### 3) The relationship between changes in mindfulness and self-compassion, and changes on the IES and BDI-II:

The correlation matrices on the next page display the changes on the self-report measures, reported for the mindfulness/self-compassion group (Table 3.3) and the relaxation groups (Table 3.4) separately. Significant correlations are presented below the table in figures. In the mindfulness group, total change in IES scores positively correlated with changes on the IES intrusiveness subscale and changes on the avoidance subscale. In support of the idea that changes in mindfulness/self-compassion were important for the improvements, specific mechanism of effect observed in the intervention, increases in mindfulness and self-compassion both correlated with decreases in BDI-II scores. In this group, reduction in BDI-II score also positively correlated with reduction in memory intrusiveness. Additionally, changes in mindfulness also positively correlated with changes in self-compassion. In the relaxation group, the only significant relationship was between changes on the IES total score and changes on each of the subscales. The significant correlations are presented in Figure 3.7 and 3.8 respectively.

Table 3.3

*Correlation matrix for the change scores in the mindfulness/self-compassion group,*

	Measure	1.	2.	3.	4.	5.
1	Change IES					
2	Change – IES intrusiveness	.78 **				
3	Change – IES avoidance	.59 **	-.05			
4	Change BDI-II	.40	.56*	-.08		
5	Change MAAS	-.30	-.28	-.12	-.53 *	
6	Change SCS	-.11	-.03	-.15	-.56 *	.60 **

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$ , two-tailed.

Table 3.4

*Correlation matrix for the change scores in the relaxation group*

	Measure	1.	2.	3.	4.	5.
1	Change IES					
2	Change – IES intrusiveness	.88 **				
3	Change – IES avoidance	.84 **	.50*			
4	Change BDI-II	.39	.42	.27		
5	Change MAAS	.12	-.15	.38	.00	
6	Change SCS	-.32	-.39	-.14	-.05	-.16

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$ , two-tailed.

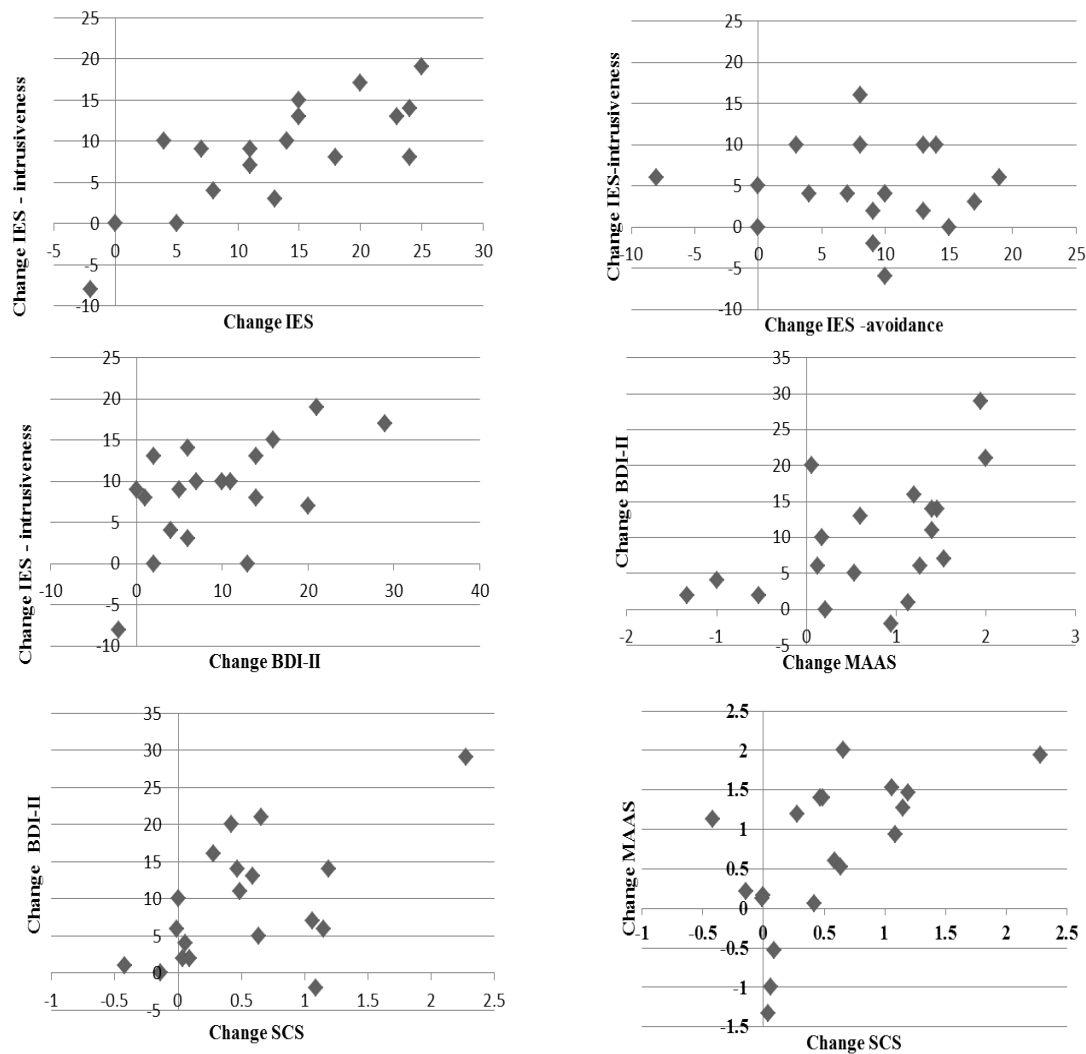


Figure 3.7. Figures displaying the significant correlations between changes on the self-report measures, in the mindfulness/self-compassion group.

It is important to note the when the outlier on the change BDI-II/change SCS Figure (bottom left) was removed, the correlation between the changes on these measures was no longer significant,  $r = .26, p > .05$ . Therefore, it may be that this finding was driven by one participant's natural fluctuation rather than due to the intervention itself.

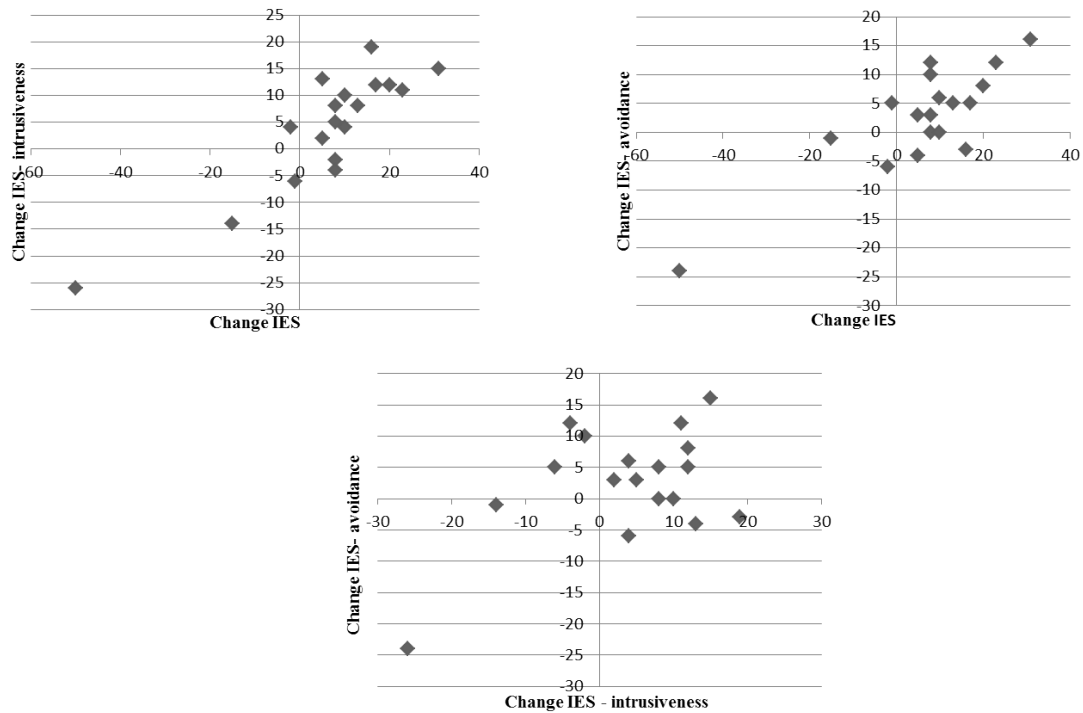


Figure 3.8. Figures displaying the significant correlations between changes on the self-report measures, in the relaxation group.

## Discussion:

The present study tested the efficacy of a short mindfulness and self-compassion based intervention on the distress associated with intrusive memories in a low mood sample. The mindfulness/self-compassion intervention was compared to a relaxation control intervention. Previous research has demonstrated that reactions to intrusive memories are more important in determining intrusion-related distress than the frequency of the memories experienced (Starr & Moulds, 2006; Williams & Moulds, 2008b). Appraisals such as ‘having this memory means there is something wrong with me’ increase the distress associated with the memory (Starr & Moulds, 2006; Williams & Moulds, 2008b) and may encourage avoidance strategies (e.g. thought suppression) that prevent successful emotional processing of the memory (Rachman, 1980). This in turn increases the frequency with which the memory is experienced.

Therefore, the goal of the present study was to test an intervention designed to reduce this emotional reactivity in a low mood sample.

Mindfulness practice helps individuals learn the skills to notice and then to disengage from negative thought patterns before they result in a downward spiral towards prolonged experiences of low mood (Segal et al., 2002; Teasdale et al., 1995).

Mindfulness-based interventions in various forms (e.g. MBSR, MBCT, brief interventions) have been shown to be effective in reducing rumination and depressive symptomatology in a variety of populations (Geschwind, Peeters, Huibers, van Os, & Wichers, 2012; Raes, Dewulf, Van Heeringen, & Williams, 2009; Teasdale et al., 2000). Being self-compassionate has also been associated with a variety of benefits on mental health (Neff, 2003b; Neff et al., 2007) and interventions designed to increase levels of self-compassion have also been shown to improve mental well-being (Gilbert & Procter, 2006; Smeets et al., 2014; Smets, Wessel, Schreurs, & Raes, 2012). Research on negative appraisals has shown that individuals react to intrusive memories both in an unmindful way (e.g. ‘because I’ve had this memory what I am trying to do will be ruined’, Moulds et al. (2008)), and in an uncompassionate way (e.g. because I can’t control this memory, I am a weak person’, Moulds et al. (2008)).

Although there are similarities between mindfulness and self-compassion, for example both promote acceptance and non-reactivity (Neff, 2009), a combined intervention was tested as both concepts were expected to bring about specific benefits to intrusive memory experience. Additionally, while mindfulness training may increase self-compassion (Kuyken et al., 2010) and vice versa (Smeets et al., 2014), this is not an explicit intention of the training. It was predicted that making both components explicit would be beneficial. In addition, mindfulness helps develop

the ability to hold a balanced view of negative emotions. This balanced awareness is required to be able to respond self-compassionately to negative experiences (Neff, 2003a). Therefore mindfulness is likely to be an important foundation of self-compassionate practice (Neff & Germer, 2013), and beginning the intervention with mindful practice was predicted to be an important component of the training programme.

Overall, there was a significant decrease in intrusion-related distress (as measured by the IES) and depressive symptomatology (as measured by the BDI-II) between the two time-points. However, contrary to predictions, the mindfulness/self-compassion intervention was no more effective at reducing intrusive-memory related distress than the relaxation intervention. This was the case both with the overall IES scores, and when the intrusiveness and avoidance subscales were analysed separately. As no previous research has looked at the impact of mindfulness or self-compassion training on intrusion-related distress, the reason behind this finding is unclear. It may reflect a lack of power, as the study was just a preliminary investigation and did use a small sample size (total  $N = 37$ ). There was also no specific frequency measure. The IES intrusiveness subscale reflects a subjective assessment of frequency – for example, ‘I thought about it when I didn’t mean to’, rated as either never/sometimes/often or always (Horowitz et al., 1979). The intervention was expected to lead to more general and sustainable changes in the way in which individuals reacted to their memories by teaching them to react differently (i.e. to respond with understanding rather than thinking ‘what is wrong with me?’). Therefore, it may be that the intervention did not last long enough for treatment-specific effects to emerge. Follow-up investigations should examine the effects of a longer intervention and include a more extensive



follow-up period. Either way, the overall reduction in IES scores (i.e. a significant reduction in distress in both groups), after a relatively short intervention, is promising and merits further investigation.

Despite the lack of an intervention-specific effect on intrusive-memory experience, an encouraging finding was there was a greater reduction in BDI-II scores following the mindfulness/self-compassion training than following the relaxation training.

Importantly, this effect was found using an active control group rather than a waitlist or treatment-as usual control group, which is often used in initial investigations into the effect of mindfulness training (Heeren & Philippot, 2011; Teasdale et al., 2000). Results therefore provide further evidence for the benefits of the brief mindfulness interventions as compared to the more traditional eight-week programmes. This parallels findings from Cavanagh et al. (2013), who found benefits of a short online mindfulness course in a student sample. Investigating the potential of briefer interventions is important because these shorter interventions are more cost-effective than longer lasting interventions. In addition, the shorter time commitment may be appealing to participants interested in embarking upon mindful practice (Tappen, 2014). The current results also support the adaptation of mindful interventions across a wider population of low mood individuals than first implicated by the RCTs conducted specifically investigating the efficacy of MBCT (Ma & Teasdale, 2004; Teasdale et al., 2000), which found that MBCT was selectively beneficial for individuals with 3 or more previous episodes of depression. The current findings are also in line with existing research that has found benefits of more general forms of mindfulness training in student and other non-clinical samples (Erogul, Singer, McIntyre, & Stefanov, 2014; Khoury et al., 2015; Smith et al., 2015). Combined,

these results are evidence that mindfulness training is beneficial beyond clinical samples. This is consistent with the growing emphasis on Positive Psychology, which is aimed at understanding what makes us flourish and succeed as way of *improving* quality of life, rather than only focusing on mental health problems (Seligman & Csikszentmihalyi, 2000).

Also in line with predictions, there was an overall significant increase in self-reported mindfulness pre to post-intervention. Importantly, this was reflected by a significant increase in self-reported mindfulness in the mindfulness/self-compassion group, but no significant change in the relaxation group. Similarly, the increase in self-compassion scores reflected a significant increase in the mindfulness/self-compassion group but no significant change in the relaxation group. This supports the notion that the intervention was targeting the processes it was designed to. Furthermore, looking at the changes that occurred on the self-report measures pre to post intervention, there was a significant positive correlation between the changes in both mindfulness and self-compassion scores and the change in BDI-II scores; participants who reported the largest changes on the mindfulness and self-compassion measures also reported the largest change in BDI-II scores. These results suggest that the efficacy of the intervention did come about through the predicted intervention-specific effects, rather than indirect effects, such as contact with researchers, group support etc. However, as noted in the results section, it appears that the correlation between changes in BDI-II and SCS was affected by an outlier; once the participant was excluded the correlation was no longer significant. It is important not to completely disregard this participant's progress as it may be that they responded particularly well to the intervention. However, it could also be the case that their large increase in self-compassion and

decrease in BDI-II reflected their natural fluctuation and could not be attributed to their participation in the intervention. Looking at the other changes, there was, no relationship between changes in mindfulness or self-compassion and any decreases in the IES scores in this same mindfulness/self-compassion group. As such, larger changes in mindfulness and self-compassion were not accompanied by larger changes in IES scores. Again, this could be a result of characteristics of the intervention itself, for example the sample size, number of sessions, or the follow-up period being too short.

Looking at baseline data provided by the questionnaires contributes to the growing work on the benefits of mindfulness and self-compassion, in this case extended to intrusive memory experience for the first time. Specifically, individuals higher in trait self-compassion reported lower levels of subjective memory-distress (as indexed by IES scores). This is further evidence that responding to negative events with self-compassion is associated with better mental health outcomes (Leary et al., 2007; Neff, 2009; Neff et al., 2007). There was, however, no relationship between IES scores and mindfulness at baseline. Items on the IES include ‘other things kept making me think about it’ and ‘I avoided letting myself get upset when I thought about it or was reminded of it’ (Horowitz et al., 1979). Therefore, it is unclear why IES scores would selectively be related to self-compassion and not to mindfulness, as both practices would promote balanced awareness of the memory over avoidant cognitive styles. It may be that responding compassionately provides additional protective effects against intrusive memory distress. The additional benefits could, for example, come through being *actively* being kind to the self (e.g. ‘I try to be loving towards myself when I’m feeling emotional pain’, Neff (2003b)), over and above the balanced awareness of

being mindful. This novel finding awaits replication in a larger sample. In addition, the correlation between higher levels of trait mindfulness and self-compassion and lower levels of depressive symptomatology, as measured by the BDI-II, are consistent with a plethora of research demonstrating mindfulness and self-compassion are associated with better mental health (Brown & Ryan, 2003; Leary et al., 2007; Neff, 2003b). The correlational data also demonstrated that BDI-II scores were positively correlated with intrusion-related distress scores, consistent both with the role of negative cognitive biases in depression (Beck, 1967) and specifically the importance of subjective ratings of intrusive memories in maintaining depressive symptoms over time (Newby & Moulds, 2011b; Williams & Moulds, 2008b).

There are some limitations to the current study. The sample consisted of individuals from the student population and local community. Time 1 measures reveal there was a good deal of variability in the sample: IES (SDs = 14.59 and 12.07 across the two groups) and BDI-II (SDs = 14.85 and 11.13) scores. It would therefore be useful for future research to assess whether the efficacy of the intervention depends on certain participant characteristics, for example perhaps the memory needs to meet a certain threshold of distress, or the effects of the intervention depends on baseline BDI-II scores etc. There is also some evidence emerging that the efficacy of mindful practice is associated with personality characteristics of the participant. For example, Vibe et al. (2015) found that students higher in conscientiousness benefited more from MBSR than students lower in conscientiousness. Although the present study was not conducted in a clinical sample, the IES scores (mean = 42.61, SD = 14.59 in the mindfulness/self-compassion group and mean = 43.42, SD = 12.07 in the relaxation group) seem to be comparable to distress levels previously reported by clinical

samples (Horowitz et al., 1979; Kuyken & Brewin, 1994), who reported means of 39.5 (SD = 17.2) and 38.2 (SD = 21.8) respectively. Despite this visual similarity, it would be useful to for future investigations to use the Structured Clinical Interview (SCID, First, Spitzer, Gibbon, Williams (2002)) to diagnose patients into clinical groups, for example look separately at currently depressed, recovered depressed and never depressed participants in order to look more thoroughly at the potential impact of specific participant characteristics on the outcome of the intervention. Participants were also not randomly allocated to the two conditions of the study. The two groups responded to two different recruitment adverts. This should be addressed in future research. Importantly, there were no group differences on any of the self-report questionnaires at baseline, suggesting the two groups had comparable characteristics, but this still does not reflect good recruitment practices. Furthermore, the relaxation group only took part in one type of training and it may therefore not have been a completely adequate control group to the mixed mindfulness/self-compassion intervention, which consisted of the two components. It would also be useful for future research to assess the extent to which participants adhered to the homework exercises they were given, in both conditions. This would indicate whether participants really engaged with the process outside of the group sessions and examine how important the homework component is to the improvements observed, for example whether participants have to engage in a high level of mindfulness practice outside of the group sessions for the observed benefits of the intervention to emerge. The assessment of homework adherence is especially important given the suggestion that depressed participants may lack motivation to complete the homework component of the intervention (Segal et al., 2002), as this potential issue may also apply to individuals experiencing low mood. It would also be important for future

research to include a more extensive follow-up period than one week and to determine whether participants continued to adopt mindfulness and self-compassion once their participation in the study was complete. Neff and Germer (2013), for example, found the benefits of Mindful Self-Compassion programme were maintained at both six month and one year follow-ups, which is an encouraging finding. However, it is currently unclear whether the benefits of a shorter intervention, such as the one conducted here, are also maintained over time. Future research should also include an explicit frequency measure, rather than just looking at frequency measured through the intrusiveness subscale of the IES, to determine whether over a longer time period changes in the way participants reacted to the memories would lead to decreases in the number of intrusions experienced. The intrusiveness subscale only reflects subjective estimates of frequency (e.g. pictures about it popped into my mind, rated on a scale of never/sometimes/often/always). Therefore it would be useful to look at a diary measure of frequency. The Ehlers and Steil (1995) model of PTSD maintenance, which provided the rationale for the current study, posits that appraisals are problematic as they encourage avoidance behaviours, which contribute to the maintenance of intrusions as they prevent successful emotional processing and changes in the meaning of the original event. It is important to determine, then, whether reducing the impact of these changes would change the actual frequency of memories experienced, versus the subjective judgments of frequency.

Despite these limitations, the study does provide preliminary support for a brief mixed intervention targeting negative appraisals of intrusive memories in a low mood sample. Although there were no mindfulness/self-compassion specific effects on the measure of intrusive memory distress, there was an overall decrease in IES scores

over the four-week period across both intervention groups. The specific effects of the intervention on this distress measure may take longer than a one-week follow-up period to emerge. While both groups showed significant decreases in BDI-II scores, in line with predictions, the difference was significant for the mindfulness/self-compassion group, and only just reached significance in the relaxation group. In conclusion, with the suggested modifications for future direction, results of this study suggest a promising basis for an intervention for individuals experiencing distressing intrusive memories and concurrent low mood.

## **Chapter four.**

# **Cognitive control and intrusive memory.**



## Introduction:

Much of the research into intrusive memories in low mood populations has focused on post-experience aspects of intrusions, for example the distress associated with the intrusions (Starr & Moulds, 2006; Williams & Moulds, 2010), or the detrimental consequences of memory avoidance (Newby & Moulds, 2011c; Williams & Moulds, 2008b). However, research has also looked at whether there is a link between underlying individual differences in cognitive control and the experience of intrusive cognitions about stressful events (Verwoerd et al., 2008; Verwoerd et al., 2009; Wessel et al., 2008).

Intrusive memories are memories of negative autobiographical events that come to mind when we do not deliberately recall them, or when we do not want to experience them (Hackmann et al., 2004). At the very least, intrusive memories can be conceptualized as a nuisance or a distraction from goals people are trying to achieve, for example trying to fall asleep or concentrate on some reading. Intrusive memories typically depict stressful emotional events, for example arguments or stressful job events, and are accompanied by distress (Newby & Moulds, 2011a; Williams & Moulds, 2007c). Indeed, many people with anxiety and depressive disorders report being plagued by recurring intrusive memories, despite attempting to control the retrieval of these memories, for example by suppressing the memory (Moulds et al., 2008; Newby & Moulds, 2011c; Williams & Moulds, 2007a). Research has highlighted factors that contribute to the persistence of intrusive memories *after* the intrusive memory is experienced, including the appraisals assigned to the intrusions (Starr & Moulds, 2006; Williams & Moulds, 2010) or the ineffectiveness of memory suppression (Wegner, 1994; Wegner et al., 1987). However, research into *why* these

memories come to mind in the first place is much less clear. How and why do these memories come to mind? Is it possible to find underlying cognitive mechanisms that make some people more prone to these types of memories than others? An intrusive memory is a memory that has not been deliberately recalled and is associated with distress. Reflection upon this definition leads to the question of whether some people are simply more prone to experiencing these memories through individual differences in cognitive control abilities. It is clear that not all individuals experience intrusive memories to the same extent in response to objectively comparable stressful life-events (Wessel, Huntjens, & Verwoerd, 2010). Consequently, it has been suggested that an individual with ‘weaker’ cognitive control may experience more intrusions than someone with ‘better’ cognitive control (Bomyea & Amir, 2011), because individuals with ‘weaker’ cognitive control would be less able to adhere to current demands and ignore external and internal reminders of the event (Wessel et al., 2008). An underlying deficit in cognitive control may then interact with other cognitive vulnerabilities present in individuals susceptible to depression, for example biases in processing of emotional information (Williams, Watts, MacLeod, & Mathews, 1988) to cause clinical levels of distress in some individuals.

Previous research investigating cognitive control in individuals who experience a high number of memories supports the idea of underlying deficits. Initial work by Klein and Boals (2001) highlighted that, in a non-clinical sample, lower Working Memory Capacity (WMC) was associated with higher IES scores that participants filled out in relation to a stressful life event. More precisely, research has also indicated the importance of proactive interference resolution (Verwoerd et al., 2009; Verwoerd et al., 2011). Resistance to proactive interference is the ability to remove information

from working memory that is no longer relevant, for example learning a new mobile phone number after buying a new one (Verwoerd et al., 2011). Proactive interference has been assessed through serial list learning tasks. For example, Verwoerd et al. (2009) looked at the role of proactive interference using the AB-AC-AB list learning paradigm. In this task, participants first learn a pair of words (the AB list: e.g. butcher-meat) then learn a second pair of words (the AC list: e.g. butcher-rope). Verwoerd et al. (2009) found that participants who reported higher IES scores, completed in relation to intrusive memories experienced the week prior to the study, required more trials to learn the AC list (having learnt the AB list) than participants with lower IES scores. This suggests a deficit in the ability to inhibit the previously relevant information (i.e. the AB list) is associated with intrusion experience. Additional evidence comes from Verwoerd et al. (2011) who measured proactive interference using the California Verbal Learning Task (CVLT). Participants completed the task then watched a film, lasting 9-minutes and depicting a murder scene. On the CVLT, participants are given two lists of words. Some categories overlap between list 1 and list 2 and some categories do not (e.g. list 1: 10 animals and 10 vegetables, list 2: 10 new animals and 10 flowers). Interference scores, measured by the impact of list 1 words on list 2 learning, predicted the number of intrusive memories experienced a week after viewing a stressful film fragment. Interference scores, however, were not associated with prior trauma or depressive symptomatology. The investigation of both personally experienced and film-induced memories is an important balancing act between providing control over the diversity of memories reported, including objective severity, time since event, duration of exposure etc., and ensuring that findings extend to real-life intrusive memories. Together, these studies suggest a role for inhibition in reducing the negative

experience of intrusive memories, both with frequency and subjective measures, and with both real-life intrusions and those induced via a stressful film clip.

The current investigation into the link between cognitive control and intrusive memories uses a different framework of cognitive control, based on the Dual Mechanisms of Control (DMC) framework (Braver et al., 2007). The DMC posits two distinct modes of control, proactive and reactive control, to account for the flexibility that is an inherent part of good cognitive control. This includes being able to switch between goal-directed behaviour and adapting to unexpected events (Botvinick et al., 2001; Braver, 2012). When interference is anticipated, proactive control prevents interference by actively maintaining goal-relevant information (e.g. maintaining ‘I need to attend colour’ in the Stroop task before stimuli presentation, Braver (2012)). Reactive control, conversely, represents a ‘late correction’ mechanism which is recruited when interference is unanticipated or preparation was insufficient, thereby representing a ‘just in time’ form of control (Braver, 2012). A central premise of the DMC is that a bias towards proactive or reactive control will depend on current task demands and individual differences, including the availability and reliability of predictive information and individual differences in fluid intelligence (Braver et al., 2007). Proactive control is more resource-demanding because contextual information has to be activated and maintained over time, therefore will only be the optimal form of control when contextual cues are sufficiently available, sufficiently reliable and the retention interval between cue and behaviour sufficiently small (Braver et al., 2007). In line with this cost-benefit trade-off, the DMC postulates that even small changes in internal states or in task demands could cause a shift from one mode to another (Braver et al., 2009). This notion of flexibility has been supported

empirically. For example, Speer et al. (2003) manipulated expected working memory load on a word memory task. Participants were presented with a list of words and, after a short delay of 3000 ms, had to indicate whether a specific word had previously been presented in the list. In one condition, the average number of words presented was four or fewer, and in the other condition, the average number of words was eight or more. Eight words were expected to exceed Working Memory Capacity (WMC) and therefore participants were expected not to be able to maintain the whole list at one time, and therefore expected to rely on a reactive strategy. The authors subsequently compared trials from both lists where the actual number of words presented was six; i.e. the difference was only in *expectation* of list length. Both behavioural and brain activation data indicated that in the short list trials, participants engaged in a proactive strategy, as they responded faster and more accurately in the low-load condition. This suggests that participants actively maintained the short list of words over the delay period. In terms of the brain activation data, during the short-list trials, activation was maintained over the delay period, also supporting the use of proactive control. Conversely, in the long-list conditions, brain activation patterns decreased over the delay, but increased following the presentation of the probe. This suggests a reactive processing style. This study is an elegant demonstration that subtle changes in task expectations can promote a shift between proactive and reactive processing. Furthermore, Braver (2012) suggests that low mood and task-irrelevant thoughts experienced as part of ruminative processes associated with low mood (see Nolen-Hoeksema (1991) for a review) will undermine the resources required for the maintenance of proactive control. Consequently, the experience of low mood is expected to be associated with reduced reliance on proactive control and increased reliance on reactive control processes (Braver et al., 2007; West, Choi, & Travers,

2010). This latter increase in reactive control is presumably an adaptive response to the former reduction in proactive control (West et al., 2010). Accordingly, West et al. (2010) determined that increased BDI-II scores were associated with reduced activation of neuronal measures associated with proactive control (measured by the amplitude of the pre-stimulus low wave) and increased activation of measures associated with reactive control (measured by the amplitude of the medial-frontal negativity) during a counting Stroop task. However, no behavioural differences were found between the groups in this study; the differences only emerged in the ERP data. This leaves the findings difficult to interpret. Saunders and Jentzsch (2014) looked at the impact of depressive symptomatology on proactive and reactive processing in the classic and emotional Stroop using behavioural measures. As summarized in the introduction chapter, in this design, proactive control is indexed by speed-accuracy trade-off adjustments (SATs), specifically the ability to use the prioritize speed versus prioritize accuracy instruction to appropriately adapt behaviour. Reactive control is indexed by Congruency Sequence Effects (CSEs); i.e. the modulation of behaviour after the experience of high conflict, specifically reflected through increased control in order to reduce the influence of the irrelevant dimension on subsequent trials. Saunders and Jentzsch (2014) found that proactive processes were unaffected by depressive symptomatology (as measured by the BDI-II) in both the classic and emotional tasks. In terms of reactive control, group differences selectively emerged in the emotional-face Stroop task, where the high BDI-II (score  $\geq 17$ ) group showed reduced CSEs in comparison to the low BDI-II (score  $< 7$ ) group. This suggests a selective deficit in reactive control processing in the face of emotional interference in the high BDI-II group. These previous findings concerning the impact of depressive symptomatology on cognitive control are important when looking at intrusion

vulnerability, as both ruminative processes and depressive symptomatology have been shown to be important factors in intrusive memory experience (Williams & Moulds, 2007c; Williams & Moulds, 2008b). However, no previous research has looked specifically at proactive and reactive processes in relation to intrusive memory experience.

In the current study, proactive and reactive control will be measured by the AX-Continuous Performance Task (AX-CPT). Specifically, this task measures the ability to use contextual information and maintain this context overtime. This task has not previously been used to look at potential control deficits in relation to intrusive memory experience. It has previously been used to assess context representation and context maintenance abilities in both aging (Braver et al., 2009) and clinical populations, including depression and schizophrenia (Barch et al., 2001; Msetfi et al., 2009). During the task, letters are presented on screen one at a time as one of four cue-target pairs. Participants are instructed to make different responses depending on the combination of letter-pairs presented. A left-handed response (keyboard press: z) is required only when the letter X is preceded by the letter A (i.e. an AX trial). Any other cue-target pairs (i.e. AY, BX and BY trials) require a right-handed response (keyboard press: m). Irrespective of the trial type, responses are made only after the second letter is presented. Therefore, the task is a measure of context maintenance as the correct response to the target letter X depends on which cue letter was presented (A or B). An important characteristic of the simple AX-CPT is that 70% of the trials are AX trials. The other 30% of trials are split equally between the three other trial types. This disproportionate number of AX trials introduces two response biases, which in turn provide more information about how individuals use context

information. The first bias induced is the tendency to make a ‘target’ response to any trial with the target letter X; the context information provided by the B-letter in a BX trial must therefore be used to override this tendency. The second bias is to make a ‘target’ response to an AY trial; in this case, good context maintenance would therefore result in an incorrect ‘target’ response. In this case, the tendency to make a ‘target’ response must be inhibited (Braver et al., 2001). Therefore, performance on both ‘target’ and ‘non-target’ trials is indicative of individual processing trends. BY trials act as control conditions because neither bias is induced in these trial types, given that neither the cue nor the probe letter indicate a ‘target’ response will be required. Therefore, on the AX-CPT, proactive control is control based on characteristics of the cue-letter and reactive control is control engaged by the target-letter (Braver et al., 2007). A proactive processing style would activate context representation based on the cue stimulus and maintain this representation over the stimulus-onset asynchrony (SOA), such that a response would be prepared in line with cue-driven expectancies (i.e. a ‘target’ response prepared after a cue-letter A, a ‘non-target’ response prepared after a cue-letter B). Therefore while proactive control is advantageous for a BX trial, it is disadvantageous for an AY trial, where the expectation generated by the cue is misleading. Deficits in proactive control will also result in poorer AX performance, although in light of the response biases induced by the disproportionate frequency of AX trials, AX performance would not be as impaired as BX performance (Braver et al., 2001). Conversely, there would be no preparatory processing following the cue letter in a reactive control and therefore when the target letter is presented, information about the cue letter needs to be retrieved to determine the appropriate response (i.e. was the cue letter an A or a B?). Reactive processing can therefore be used to prevent an error when the cue-driven



expectancy is false (i.e. in an AY trial). Deficits in proactive control could result from two types of impairment; either the context representation was not sufficiently strong in the first place (i.e. cue-related information was not optimally used), or it could reflect an inability to adequately maintain this representation over-time. In order to differentiate between these two possibilities, half the trials in the task comprise of a short SOA between cue and target-letter, and half the trials have a longer SOA. If context maintenance is the specific impairment, then BX performance would be poorer in the long SOA trials compared to the short SOA trials, while AY performance would improve. If context maintenance is intact then BX performance will be stable or improve with the longer SOA, while AY performance will be stable or worsen with time (Paxton et al., 2008).

Despite the lack of existing research using the AX-CPT to investigate intrusion vulnerability, there has been some work exploring how low mood impacts AX-CPT performance on the AX-CPT. Msetfi et al. (2009) looked at the impact of depressive symptomatology (as measured by the BDI-II) on task performance. Students with BDI-II scores  $\geq 9$  showed impaired context maintenance (i.e. deficits in maintaining activated information over time) compared to non-depressed students (BDI score  $< 8$ ). During the long (10 s) SOAs only, high BDI-II participants made more errors on the BX trials than any other trial types, while low BDI-II participants made more AY errors, which was expected given the expectancy bias generated by the high frequency of AX trials (Msetfi et al., 2009). This pattern specifically suggests that high BDI-II participants did not seem to maintain the context information over the long SOA, whereas participants with low BDI-II scores could adequately maintain this information. These results coincide with the conclusion drawn by West et al. (2010)

that low mood influences cognitive processing and changes an individual's dependence on proactive and reactive processing. Previous work on intrusion vulnerability has not differentiated between proactive and reactive control processes. However, given that the ability to be flexible between the two modes of control is an essential aspect of cognitive control (Braver, 2012; Braver et al., 2007), it is important to assess whether individuals experiencing a high number of memories perform differently on this simple task than individuals experiencing a lower number of memories. In terms of potential differences between intrusive and more everyday forms of negative involuntary memories discussed in the introduction chapter, the study will look at both potential types of negative involuntary memory. The Intrusive Memory Interview will be used to measure traditional forms of intrusive memory, and the diary measure will be used to measure any negative involuntary memory participants experience during a one-week period.

### **The present study:**

In summary, the goal of the present study is to ascertain whether there is a link between AX-CPT performance, measuring context processing and context maintenance abilities, and intrusive memory experience in a non-clinical sample. Various indices of intrusive memory experience will be assessed; incorporating both frequency and consequences aspects of memory experience. In turn, frequency of intrusive memories will be assessed two ways. Firstly, participants will be asked to retrospectively report the number of 'spontaneous' memories about a 'past negative/event/circumstance/situation' (Hackmann et al., 2004) they experienced 7 days prior to completing the task, via the Intrusive Memory Interview. This will termed the retrospective measure and the measure is in line with previous research

into intrusive memories (Newby & Moulds, 2011a; Williams & Moulds, 2007c; Williams & Moulds, 2008a, 2008b). As a second frequency measure, participants will also be asked to keep a diary of intrusive memories experienced during the seven days after completing the task. According to the definitions provided by Kvavilashvili (2014), this measure will not address whether the memories recorded in the diary ‘repeatedly intrude upon consciousness’ (p. 101), which is her criterion for an intrusive memory, as compared to a negative involuntary memory. Therefore, this is a general measure of the number of negative involuntary memories experienced, because the memories reported in the diary are not necessarily experienced repeatedly. In both cases, the important question is whether individual differences in cognitive control are linked to the number or the consequences of unrecalled negative memories.

The second index of intrusive memory experience will look at the consequences of the memory. This is in line with research highlighting the importance of the way individuals react to their memories (Moulds et al., 2008; Newby & Moulds, 2010; Starr & Moulds, 2006) in determining intrusive memory experience, rather than simply being associated with the frequency of the memory. In further support of the importance of subjective assessments of memories reported by low-mood participants, the memories typically concern commonplace events most individuals have experienced, such as arguments or embarrassing situations (Brewin et al., 1996b; Williams & Moulds, 2007c), rather than being of exceptional or traumatic life-events, for example memories of car crashes or life-threatening events, as observed in PTSD (Ehlers & Steil, 1995). Furthermore, in terms of negative involuntary (i.e. not necessarily repetitive) memories, Kvavilashvili and Schlagman (2011) determined that the involuntary memories reported by dysphoric individuals during their vigilance

task, discussed in the introduction chapter, were not objectively more negative than the negative memories reported by non-dysphoric individuals (as rated by the researchers), even though the dysphoric individuals rated their memories as being more negative. This is consistent with the idea that negative cognitive biases associated with low mood individuals (Beck & Alford, 2009) extend to involuntary memory systems (Watson et al., 2012). Therefore, it is important to determine whether some people are more prone to experience these negative unrecalled memories more often, or whether it is the consequences of these memories that become so problematic. The consequences aspect of intrusion experience will be also assessed in two different ways. The IES will be used to assess the relationship between task performance and subjective affective impact specifically in relation to the intrusive memory reported during the Intrusive Memory Interview (e.g. ‘any reminder brought back feelings of it’, ‘I had waves of strong feelings about it, Horowitz et al. (1979)). The RRS will then be used as a measure of trait ruminative tendencies (i.e. general responses to sad mood and feelings). Braver (2012) predicted that rumination would specifically impact proactive control processes. However, previously Msetfi et al. (2009) did not find any deficits related to trait rumination on the AX-CPT. Therefore, it is unclear how rumination will impact task performance. In light of the occurrence of intrusive memories in depressed and low mood individuals (Moulds et al., 2008; Newby & Moulds, 2010, 2011c), the study will also investigate the role of depressive symptomatology (as measured by the BDI-II) on task performance. As well as a mean split analysis of the BDI-II data, a second analysis using a more extreme BDI-II group split will be used. This is to more sensitively establish any effects of depressive symptomatology on task performance and to counteract the limitation of mean/median split based analyses. Therefore,

following Saunders and Jentzsch (2014), the high extreme BDI-II group will consist of participants with a BDI-II score  $\geq 17$  and the low group will consist of participants with a BDI-II score  $< 7$ . This method of selection ensures a high ‘true positive’ rate for depression in the high group (Beck et al., 1996, Saunders & Jentzsch, 2014) and minimal endorsement of depressive symptomatology in the low group.

During the results section, the correlations between the measures will also be presented. For all these dependent variables, groups (high versus low) will be determined using mean splits. The mean, as opposed to the median, was used to dichotomize the groups as the mean number of intrusive memories (mean = 4.99, SD = 5.13) was higher than the median (median = 3.75). Therefore, a mean split was used to make the task more sensitive at uncovering a potential link between intrusive memory experience and cognitive control, as the split would be conducted at a slightly higher value.

### **Predictions:**

#### **1) Overall task:**

Significant main effects of SOA (short, long) and condition (AY, BX, BY) are predicted. Accordingly, reaction times (RTs) are predicted to be faster and error rates lower for the long SOA compared to the short SOA trials, as in the long SOA trials participants have more time to use the cue-based information to prepare a response. There are also expected to be significant differences in performance between AY, BX and BY trials; post-hoc comparisons are predicted to show higher RTs and error rates for AY as compared to both BX and BY trials, as in AY trials participants are expected to incorrectly proactively prepare a ‘target’ response after the cue-letter A is presented. There is also expected to be a difference between BX and BY trials, with higher RTs and error rates to BX trials given the potentially misleading information

given by the target-letter X, whereas in BY trials neither the cue nor the probe letter indicates a ‘target’ response would be required.

## **2) Group comparisons:**

It is predicted that cognitive control, as indexed by the AX-CPT, will be affected by intrusive memory frequency (both retrospective and diary measures) and consequences of the memory (both the IES and RRS measures) and depressive symptomatology (as measured by the BDI-II). Specifically, individuals reporting a higher number of memories and higher scores on the other self-report measures (IES, RRS and BDI-II) are predicted to show less proactive control (cue-based processing) and more reactive (target-based processing) control, indexed through better performance on AY trials, but impaired BX performance. Individuals reporting a lower number of memories and scoring lower on the self-report measures are expected to show more reliance on proactive control, therefore are expected to perform better on BX trials, but more poorly on AY trials.

## **3) Correlations between intrusive memories and questionnaires:**

The relationships between the measures will be examined to determine the characteristics of the sample. Newby and Moulds (2011a) found no significant between group differences in the number days on which currently depressed, recovered depressed and never depressed individuals had experienced an intrusive memory over the previous week, although the never depressed group had experienced the memory fewer times within a day than the currently depressed group. Therefore, it is unclear whether the correlation between the memory frequency (retrospective or diary rating) and BDI-II score will be significant on a continuous measure of

depressive symptomatology. Previous research suggests that the frequency of intrusive memories does not correlate with intrusive memory-related distress, as measured on a 100-point scale (Starr & Moulds, 2006; Williams & Moulds, 2007c). However, previous research does suggest there is a significant positive correlation between subjective distress, as measured by the IES, which is the measure of subjective distress to be used in current study, and BDI-II scores (Hauer, Wessel, & Merckelbach, 2006). This is consistent with the suggestion that negative cognitive biases in low mood individuals are also reflected in the experience of both involuntary and voluntary memories (Watson et al., 2012). A significant correlation between trait rumination and intrusion-related distress (measured by the IES) is also expected to be significant based on previous research, which used a 100-point rating scale for distress (Starr & Moulds, 2006; Williams & Moulds, 2008b), rather than the IES used in the current study. A positive significant correlation between RRS and BDI-II is also expected also on the basis of existing research (Nolen-Hoeksema, 1991; Spasojević & Alloy, 2001).

## **Methods:**

### *Participants:*

The study was given ethical approval by the University Teaching and Research Ethics Committee (UTREC). Participants volunteered for the study through the SONA system (which is open to students and the local community) on the basis of having recently experienced intrusive memories and being fluent English speakers.

Participation involved two sessions (1 hour and 30 minutes total). In total 38 participants took part, 1 of whom was excluded due to reporting a frequency of intrusive memories more than 3 SDs above the mean (= 54 memories, details below) and 2 of whom withdrew before the second session. No other data fell more than 3

SDs above the mean, therefore no other data were excluded. Consequently, 35 participants remained for data analysis (26 female, 9 male, age range 18-29). Power analysis revealed that a sample size of 34 would be required to detect a medium effect size at the 95% confidence interval using the .05 criterion of statistical significance. Therefore, the sample size was relatively small. Participants were reimbursed £10 total for their time.

Stimuli were single letters presented 40 mm x 40 mm in size, presented in black font and presented centrally on a white screen. The cue letter consisted either of an A or a B, and target letters consisted either of an X or a Y. The target-letter X required a 'target' response (keyboard press: z) only if preceded by the letter A. Any other combination of cue-target letter pairs (i.e. AY, BX, BY trials) required a 'non-target' response (keyboard press: m). Each trial began with a fixation cross on screen (300 ms), followed by the cue-letter (300 ms), followed a blank screen (SOA: 700 ms or 4700 ms), followed by the target-letter (presented until response) and finally a blank screen was presented (300 ms). See Figure 4.1 for an example of a single trial. The task was made up of 4 blocks, each containing 100 cue-target-pair trials. The SOA was randomly chosen, and each SOA was presented equally often in each block. 70% of trials were AX trials, the rest were divided equally between AY, BX and BY trials (10% each), with trial order randomly chosen within each block. At the end of each block, participants were shown their mean accuracy rate for the previous block (as a %) and could take a short break before continuing. Participants first completed 2 practice blocks (of 10 cue-target pairs), and were given the mean accuracy rate after each practice block and the opportunity to ask the researcher any questions before beginning the experimental trials.



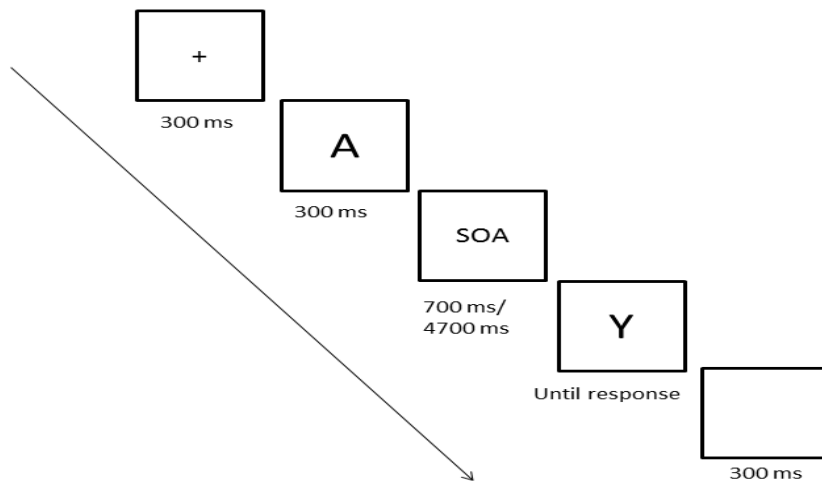


Figure 4.1. Example of a single trial on the AX-CPT.

#### *Procedure:*

Participants first completed the AX-CPT task, lasting approximately 30 minutes. Participants were then taken through the Intrusive Memory Interview and completed the IES, BDI-II and the RRS self-report questionnaires in a randomized order. Participants were then given the instructions for keeping the diary over the next 7 days, after which they returned to the research laboratory to hand in their diaries, to be debriefed and to be reimbursed.

#### **Results:**

Firstly, the overall task data will be presented, followed by the group comparisons. The overall task data will be analysed using a 1-way repeated-measures ANOVA with the within-subjects factor SOA (short, long) for the ‘target’ trials. For the ‘non-target’ trials, a repeated-measures ANOVA with the within-subjects factors SOA (short, long) and condition (AY, BX, BY) will be conducted. The following group splits will then be conducted; retrospective, diary, IES, RRS and BDI-II. The group ‘target’ trial comparison will comprise of a 1-way repeated-measures ANOVA with the within-

subjects factor SOA (short, long) and the between-subjects factor (as defined in the following sections). For the ‘non-target’ trials, this will comprise of a repeated-measures ANOVA with the within-subjects factors SOA (short, long) and condition (AY, BX, BY) and the between-subjects factor. For the between-group analyses, only effects involving the factor group will be reported. Bonferroni corrections were made to post-hoc comparisons to minimise the risk of a Type II error. However, given the relatively small sample size, Bonferroni corrections were not made to the initial between-group comparisons.

## 1) Overall Task Data:

Mean RTs and error rates for all trial types are displayed in Figure 4.2 below, split by short (700 ms) and long (4700 ms) SOA trials.

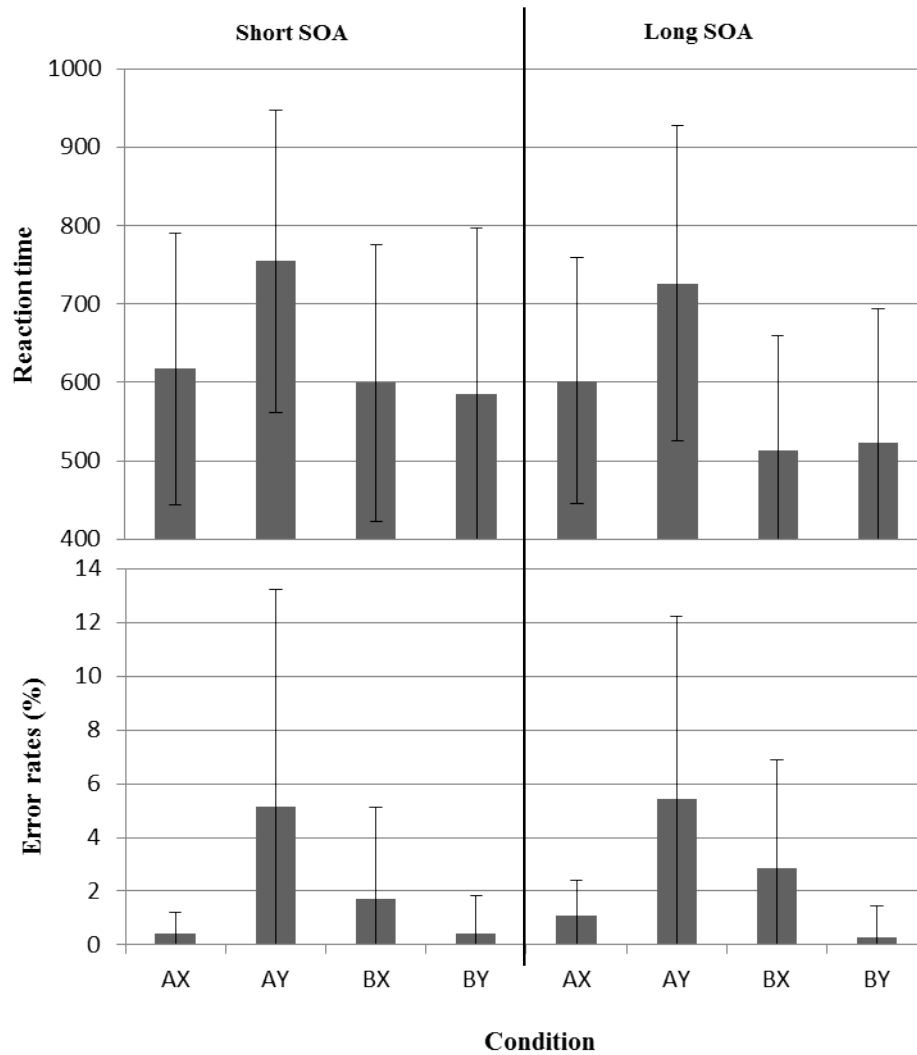


Figure 4.2. Mean RT and error rates (with standard error bars) to all trial types, split by short and long SOA trials.

### i) 'Target' (AX) trials:

**Reaction Times (RTs):** The main effect of SOA was not significant,  $F(1, 34) = 1.67$ ,  $p > .05$ .

**Error rates:** Kolmogorov-Smirnov tests showed that the error data were not normally distributed,  $D_s(35) > 0.22$ ,  $p < .01$ . The data were therefore arcsine transformed before being submitted into a repeated-measures ANOVA. However, the means reported in the text and shown in the figures are based on the original data. There was a significant main effect of SOA,  $F(1, 34) = 15.29$ ,  $p = .01$ , partial  $\eta^2 = .31$ . A higher percentage of error rates were made on the long SOA trials (mean = 1.10%, SD = .22) than on the short SOA trials (mean = 0.43%, SD = .13).

**ii) ‘Non-target’ (AY, BX, BY) trials:**

**RTs:** There was a significant main effect of SOA,  $F(1, 34) = 23.62$ ,  $p = .01$ , partial  $\eta^2 = .41$ . RTs were significantly faster for the long SOA (mean = 587 ms, SD = 28.2) than for the short SOA trials (mean = 646 ms, SD = 30.8). The main effect of condition was also significant,  $F(2, 68) = 104.21$ ,  $p = .01$ , partial  $\eta^2 = .75$ . Pairwise comparisons were subsequently conducted. After Bonferroni corrections, the  $p$  value needed to be less than .02 for the effect to reach significance. These comparisons revealed this reflected slower RTs for AY trials (mean = 740 ms, SD = 32.55) than for both BX (556 ms, SD = 25.81) and BY (mean = 554 ms, SD = 31.59),  $F_s > 110.52$ ,  $p < .01$ , both partial  $\eta^2 > .78$ . The difference between BX and BY trials, however, was not significant,  $F(2, 68) = .04$ ,  $p > .05$ . The condition x SOA interaction was significant  $F(2, 68) = 13.67$ ,  $p = .01$ , partial  $\eta^2 = .32$ . There was a significant difference between the two SOAs for BX (85 ms) and BY trials (62 ms), both  $F_s > 14.55$ , both  $p < .01$ , both partial  $\eta^2 > .30$ , but no significant difference (after Bonferroni corrections) between the two SOAs for AY (28 ms) trials,  $F(1, 34) = 4.41$ ,  $p = .05$ , partial  $\eta^2 = .11$ .

**Error rates:** The main effect of condition was significant,  $F(2, 68) = 19.94$ ,  $p = .01$ , partial  $\eta^2 = .37$ . Pairwise comparisons (Bonferroni corrected) revealed this reflected a significant difference between the percentage of errors made between AY (mean = 5.28%,  $SD = 1.07$ ) and both BX (mean = 2.23%,  $SD = .54$ ) and BY trials (mean = 0.36%,  $SD = .15$ ), both  $F_s > 8.60$ ,  $ps < .019$  and both partial  $\eta^2_s > .21$ . Significantly more errors were also made to BX trials than to BY trials,  $F(1, 34) = 14.83$ ,  $p = .01$ , partial  $\eta^2 = .30$ . No other effects were significant,  $F_s < 1.31$ ,  $ps > .05$ .

**Task summary:** Some predictions of the task were met. On ‘target’ trials, more errors were made in the long SOA trials, and for ‘non-target’ trials, RTs were faster for the long SOA trials. This suggests participants used the longer SOA to prepare a response based on the cue-letter, i.e. results show that participants demonstrated proactive control. This is also supported by the finding that participants were slower and made more errors to AY trials, where the context suggested by the cue-letter was misleading. However, the lack of BX/BY difference in the RT data is problematic. It suggests that participants gained enough information for the cue-letter B to prepare a ‘non-target’ response and were able to adequately maintain this information over time, without needing to rely on the target-letter for any context information. The BX/BY difference did emerge in the error data, with significantly more errors made in BX trials as compared to BY trials. This reflects an important characteristic of the task. However, the overall number of errors was low. This reduced the sensitivity of the task to find group differences in reactive control when conducting the group comparisons. The effect of SOA also differed depending on the trial type; responses were only significantly faster for long SOA trials, as compared to short SOA trials, when the cue-letter was B and therefore the correct response was already clear.

## 2) Group comparisons:

Table 4.1 displays the descriptive statistics for each of the measures. It also explains the composition of the high and low groups based on mean splits.

Table 4.1

*Means and standard deviation (SD) for the self-report scales and the composition of the groups based on mean splits.*

Variable	Mean	S.D.	Group split value	N high	N low
Retrospective	4.99	5.13	$\geq 5$	14	21
Diary	2.46	1.48	$\geq 3$	16	19
IES	33.34	13.49	$\geq 33$	16	19
RRS	48.74	13.03	$\geq 49$	16	19
BDI-II	13.49	9.08	$\geq 13$	18	17
Extreme BDI-II	14.54	10.59	High $\geq 17$ , Low $< 7$	13	11

As found in the previous study, the intrusive memories that participants reported during the Intrusive Memory Interview were consistent with existing research into intrusive memories (Brewin et al., 1996, Newby & Moulds, 2012). These included relationship/family problems (e.g. argument with a school bully in Primary School, seeing parents argue), work/school issues or personal failure (e.g. remembering a difficult University exam, getting a bad essay grade back) and illness/death of another (e.g. learning that a Grandparent had died). The mean rating of intrusive memory distress was 65.45 out of 100 (SD = 19.84).

**i) ‘Target’ (AX) trials:**

Tables 4.2 and 4.3 below display the F-values for ‘target’ trials for RT and error data respectively. No values were significant; performance to ‘target’ trials was not affected by any of the between-subjects comparisons.

Table 4.2

*F-values for **reaction times** to ‘target’ trials. No values were significant.*

	<b>Retrospective</b>	<b>Diary</b>	<b>IES</b>	<b>RRS</b>	<b>BDI-II</b>	<b>Extreme BDI-II</b>
<b>Group</b>	0.86	1.78	0.31	1.04	1.62	0.73
<b>Group x SOA</b>	2.83	0.38	0.44	0.70	0.45	0.39

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$*

Table 4.3

*F-values for **error rates** to ‘target’ trials. No values were significant.*

	<b>Retrospective</b>	<b>Diary</b>	<b>IES</b>	<b>RRS</b>	<b>BDI-II</b>	<b>Extreme BDI-II</b>
<b>Group</b>	0.78	0.17	0.22	0.35	0.02	0.15
<b>Group x SOA</b>	0.20	0.01	0.18	0.24	0.37	0.14

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$*

ii) ‘Non-target’ (AY, BX, BY) trials:

Tables 4.4 and 4.5 display the F-values for ‘non-target’ trials for each between-group variable, for reaction times and error rates respectively. There was only one significant effect, which was found in the error data and involved the diary group categorization. No effects were significant in the RT data. The significant F-value is presented in bold and the corresponding figure presented below the table.

Table 4.4

*F-values for **reaction times** to ‘non-target’ trials. No values were significant.*

	Retrospective	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.43	0.42	0.59	1.22	1.89	0.38
<b>Group x condition</b>	0.35	0.01	0.76	0.75	1.19	1.65
<b>Group x SOA</b>	1.05	1.53	0.09	0.74	0.39	0.02
<b>Group x condition x SOA</b>	2.74	0.15	2.09	0.92	2.60	0.86

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$*

Table 4.5

*F-values for **error rates** to ‘non-target’ trials. Significant F-values are presented in bold.*

	Retrospective	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.01	0.01	0.40	1.11	0.45	0.27
<b>Group x condition</b>	1.14	0.51	0.16	0.63	0.18	0.51
<b>Group x SOA</b>	1.62	<b>6.96 **</b>	0.01	0.05	0.13	0.03
<b>Group x condition x SOA</b>	0.90	0.93	0.62	0.65	0.98	0.69

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$*

The diary group x SOA interaction was significant,  $F(1, 33) = 6.96$ ,  $p = .01$ , partial  $\eta^2 = .17$ . The high diary group made significantly more errors in the long SOA trials,  $F(1, 15) = 6.86$ ,  $p = .02$ , partial  $\eta^2 = .31$ , whereas there was no significant difference in the number of errors made between the two SOAs for the low diary group,  $F(1, 18) = 0.85$ ,  $p > .05$ . This effect is displayed in Figure 4.3 below.



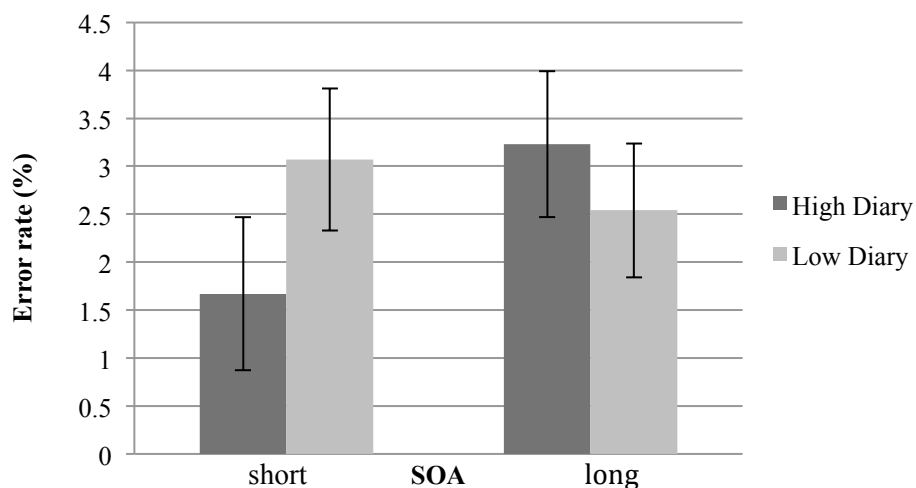


Figure 4.3: Mean error rates (as a %, with standard error bars) over the 2 SOAs, split by high versus low diary group.

*Group comparisons summary:* Task performance was not affected by any of the between-subjects variables, except for one significant finding in the error data. Here, participants in the high diary group showed a deficit in proactive control. Specifically, the high diary group made significantly more errors in the long SOA than in the short SOA trials, which was the opposite pattern to the low diary group, who made (non-significantly) fewer errors in the long SOA than the short SOA. This suggests that experiencing a high number of negative memories impairs the ability to maintain context overtime. However, the overall low error rates means this finding should be interpreted with caution.

### 3) Correlations between intrusive memories and questionnaires:

Table 4.6 below displays the correlations between the self-report measures. In this sample, the more intrusive memories an individual reporting having experienced the week before their participation in the study, the higher the intrusive-memory related distress and the higher the depressive symptomatology they reported. There was also

a significant correlation between the IES and RRS scores; individuals reporting higher trait levels of rumination reported more intrusion-related distress. This conceptually makes sense, as both scales are looking at the affective impact of a negative cognition, whether specifically related to intrusive memories, or negative cognitions more generally. The significant positive correlation between RRS and BDI-II scores replicates a substantial amount of existing literature showing that rumination is an important cognitive process in depression (Nolen-Hoeksema, 1991; Spasojević & Alloy, 2001). In general, the correlations found suggest that there was sufficient variation in the sample, even if this did not translate into group differences in cognitive control. Figure 4.4 displays the significant correlations.

Table 4.6

*Correlations between the self-report measures. Significant correlations are displayed in figures below.*

	Measure	1. Retrospective	2. Diary	3. IES	4. RRS
1	Retrospective				
2	Diary	0.14			
3	IES	.41 *	.08		
4	RRS	.28	.07	.63 **	
5	BDI-II	.42 *	.01	.63 **	.73 **

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$ , (two-tailed).

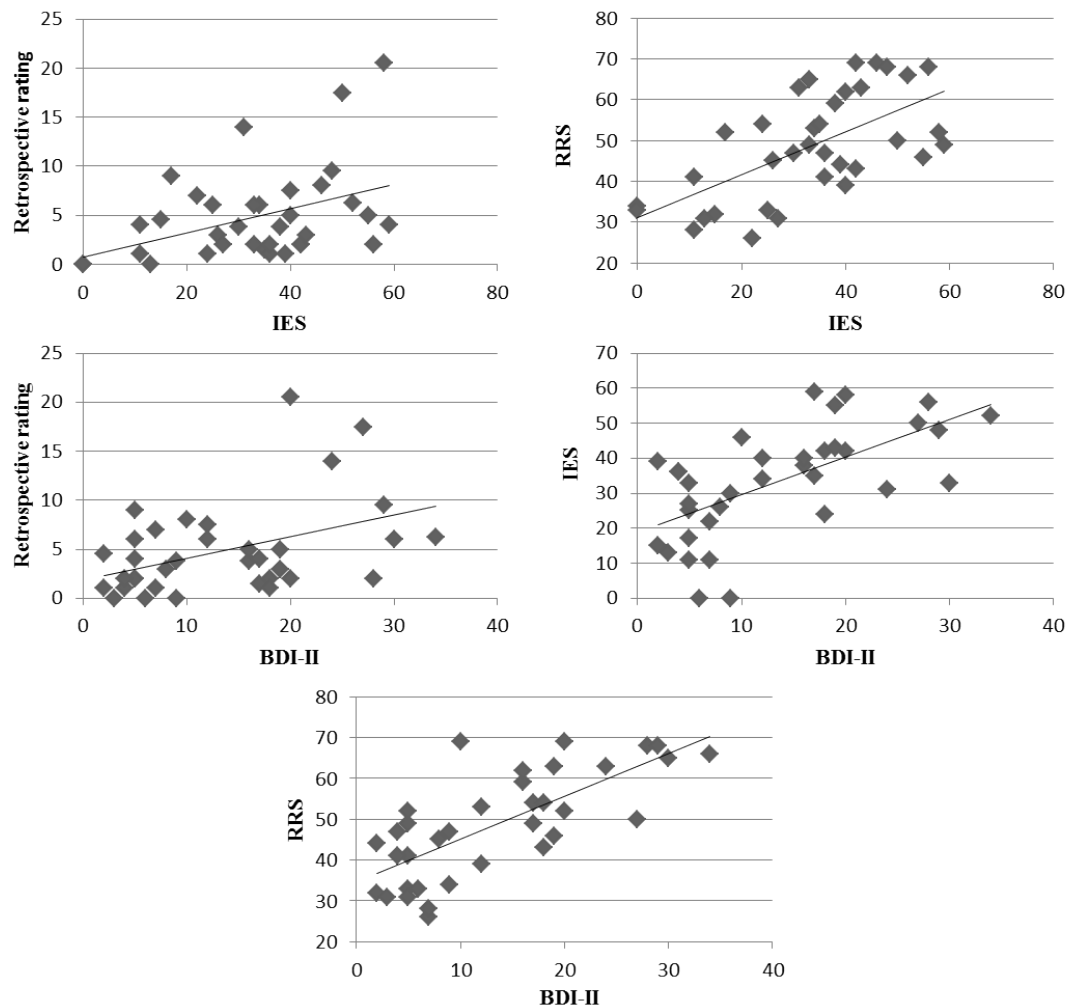


Figure 4.4. Displaying the significant correlations between the self-report measures.

## Discussion:

The current study investigated whether individual variability in cognitive control, assessed by the AX-CPT task, would account for why some individuals are more susceptible to experiencing high numbers of intrusive and negative involuntary memories, or suffer more from the consequences of experiencing these memories. Given that intrusive memories are memories that have not been deliberately recalled, are memories about past negative events and are distressing to experience (Newby et al., 2014; Newby & Moulds, 2011c), it has been suggested that people with ‘weaker’ cognitive control may be more prone to experiencing these unwanted memories (Wessel et al., 2010; Wessel et al., 2008). Accordingly, Bomyea and Amir (2011)

suggest that individual differences in the cognitive control relate to the number of intrusions experienced. This idea is supported by previous research in student samples, specifically individual differences in the ability to resolve proactive interference, using both the trauma-film paradigm (Verwoerd et al., 2011; Wessel et al., 2008) and self-reported intrusive memories (Verwoerd et al., 2009). The present study sought to extend this research by investigating the role of basic cognitive control abilities in intrusion vulnerability, using a task based on the Dual Mechanisms of Control (DMC) framework, which distinguishes between proactive and reactive control (Braver et al., 2007). On the AX-CPT, performance to different trial types reflects individual differences in cognitive processing; good context representation (i.e. using information provided by the cue letter) will be beneficial for some trial types (BX trials), but not for others (AY trials). As posited by the DMC, therefore, proactive control is beneficial for BX trials but not for AY trials, whereas reactive control is beneficial for AY trials but not for BX trials (Braver et al., 2007). The goal of the present study was to ascertain whether differences in proactive and reactive cognitive processing would explain why some individuals are more prone to experiencing memories that have not been deliberately recalled than individuals who do not experience intrusive or negative involuntary memories on such a regular basis.

On the AX-CPT, cue and target information generally affected performance. RTs were faster and error rates lower for both BX and BY trials than for AY trials, suggesting that participants used information about the cue, as well as the target probability (70% of trials were AX trials), to prepare responses following the cue letter, which in AY trials turned out to be misleading. However, contrary to earlier studies on the AX-CPT (Braver et al., 2001), there was no difference in RTs between

BX and BY trials. These findings suggest that participants gained sufficient information from the cue-letter B and were consequently able to prepare the appropriate 'non-target' information, without needing to rely on any target-based processing. Importantly, this was the case for both SOAs. The BX/BY difference did emerge in the error data. As predicted, participants made more errors to BX trials than to BY trials, suggesting some degree of reactive, i.e. target-based, processing. However, the low overall number of errors reduced the sensitivity of the task to find group error-related differences. It seems that the SOA was not long enough to encourage much target-letter based processing, as participants could easily maintain the context (i.e. information portrayed by the cue-letter) over both the short and long duration intervals. This limitation will be discussed in more detail later. There was a significant interaction between condition and SOA, which revealed a significant difference in RTs between the two SOAs for BX and BY trials, but not for AY trials. This is further support that participants could fully prepare a 'non-target' response following a B letter, as the longer the SOA, the more they could prepare and therefore the faster they were to respond with a 'non-target' response when the target-letter was presented. In contrast, the expectancy violation leading to slower RTs on the AY trials (where preparatory processing for a 'target' response had to be overridden) was similar across SOAs. Therefore it is likely that only group differences in proactive (cue-based) processing (Braver et al., 2007) would have been discernable with the current set of data.

In fact, the only between-group difference that emerged was on the diary group categorization, in terms of a differential impact of the two SOAs on the percentage of errors made to 'non-target' trials. Specifically, the high diary group made

significantly more errors in the long SOA trials, while the low diary group made more errors in the short SOA trials. This suggests that individuals who experience a high number of negative involuntary memories (importantly these are not necessarily intrusive, repetitive, memories according to Kvavilashvili (2014)) are impaired in maintaining the context information provided by the cue over time, consistent with the idea of a deficit in proactive control (Braver et al., 2007). However, as noted above, the overall low error rate across both ‘target’ and ‘non-target’ trials limits the strength of this conclusion. It is, nonetheless, some indication of an involuntary-memory related deficit in proactive control. There were no other group differences in the frequency measures, either in the retrospective ratings or the diary measures. That only one finding was significant suggests against the idea that individuals with ‘weaker’ cognitive control are generally more susceptible to experiencing a higher frequency of intrusive memories (Wessel et al., 2010; Wessel et al., 2008), specifically not on a basic measure of context maintenance abilities. Given that the aim of the study was to establish whether there was a basic difference in the ability to prevent upsetting or unwanted memories coming to mind, both intrusive and negative involuntary measures were deemed appropriate for this initial investigation; the study was looking at a memory for any negative event which comes to mind without being deliberately recalled. However, aside from the initial indication of a proactive deficit in the high diary group, task performance was not overall affected by the frequency of negative memories on either measure. A lack of between-group differences in AX performance also supports the lack of proactive deficit. Future research should more thoroughly investigate the potential intrusive/negative involuntary memory distinction to determine to what extent the memories recorded through the diary pertain to the

same event, or whether the memories are more everyday 'one-off' experiences.

Memory content analysis may be a good method of addressing this issue.

Along with the frequency measures, the consequences of the memory were also assessed. Firstly, Impact of Event Scale (IES) scores, completed in relation to the memory highlighted in the Intrusive Memory Interview, were investigated as a measure of subjective level of 'intrusiveness' of the intrusive memory participants reported. It seems logical that the appraisal aspect of intrusions, rather than simply the number of memories experienced, would be related to indices of cognitive control. Conceivably, individuals who experience their intrusive memories with higher levels of distress would be more motivated to try and avoid experiencing the memory. This may be how cognitive control abilities become important in regulating these memories. Investigating the relationship between IES scores and task performance also incorporates some of the diversity in events reported by participants which simply looking at frequency measures does not. One participant may have experienced their memory only two times during the previous week, but be more upset by, and therefore try to recruit more control over, these two memories than another participant who experiences five less distressing intrusive memories over same time period. However, once again there were no significant effects involving IES group, suggesting that the lack of substantial frequency findings was not due to the crudity of the frequency measures. Trait rumination was also looked at as a consequence measure. However, task performance also did not vary as a function of rumination, suggesting against the prediction that some individuals are more vulnerable to getting 'stuck' on their intrusive memories due to deficits in cognitive control, or that rumination would impact proactive control and the maintenance of

context information (Braver, 2012). The lack of rumination-related impairments is consistent with Msetfi et al. (2009) who also looked at AX-CPT performance and found no difference between high and low ruminators.

The role of general low mood on task performance was also investigated. This was important given it has consistently been demonstrated that intrusive memories are a key symptom of depression that interact with ruminative thought processes to maintain symptoms of low mood (Newby & Moulds, 2011c; Starr & Moulds, 2006; Williams & Moulds, 2010). Previous research making the distinction between proactive and reactive processes to investigate the impact of low mood has found that higher BDI-II scores were associated with decreased neuronal indices of proactive control and increased neuronal indices of reactive control (West et al., 2010).

However, these differences only emerged in the ERP data. There were no behavioural differences observed. As discussed earlier, previous research using the AX-CPT has found depressive-related impairments on the AX-CPT. Msetfi et al. (2009) found that high BDI-II scorers ( $BDI-II > 9$ ) made significantly more errors on BX trials than on AY trials only in the long SOA conditions, suggesting a specific deficit in *maintaining* context, rather than a deficit in using context more generally.

Performance was similar to non-depressed participants for the short SOA. Conversely, the present study did not find any differences between high and low BDI-II scorers on the AX-CPT task, in either the short or the long SOA. Methodological differences may account for these differences. The most important difference was that Msetfi et al. (2009) compared a short (1000 ms) SOA to a long SOA (10000 ms), which again suggests the long SOA (4700 ms) was not long enough in the present study.

Additionally, participants in the Msetfi et al. (2009) study were only given 1000 ms to



respond to the target-letter, whereas in the current study the target-letter remained on screen until a response was made. Furthermore, they manipulated the SOA between-subjects rather than within-subjects, so the trade-off between cue and target processing may have been subtler, as flexibility was not compared within the same group of individuals. Finally, Msetfi et al. (2009) also only looked at differences in the *error rates* rather than reaction times, and error rates were low in the current set of data.

Interestingly, the lack of proactive deficits as a function of depressive symptomatology on a non-valenced task is consistent with Saunders and Jentsch (2014). On both the classic and emotional Stroop tasks, they found that high BDI-II participants made similar speed/accuracy adjustments (i.e. could make goal-related changes to their behaviour) to low BDI-II participants, in both the classic and emotional Stroop tasks. They did find differences in reactive control, in the emotional, but not the classic Stroop task. This finding awaits replication in the next study but does initially support the idea that the low mood individuals are not characterized by a deficit in proactive control.

In terms of the correlations between the measures, it is interesting to consider the relationship between the two frequency measures, as they were not significantly correlated. As previously discussed, the two measures theoretically assessed different subtypes of negative involuntary memories. Although it was argued that the diary measure potentially incorporated a wider type of negative involuntary memory than the intrusive memory measure, the number of memories in the diary was actually significantly lower than the retrospective measure ( $t(34) = 2.90, p = .01$ ). It is

important to note that the measures also assess the number of memories experienced over two different week periods, therefore direct comparisons cannot be made. In addition to these potential theoretical differences, the way in which the measures are collected may have an effect on the number of memories reported. Firstly, rating intrusive memories retrospectively may have meant participants unintentionally overestimated their experiences of intrusive memories when being asked to think back over the past 7 days, especially in view of the negative cognitive biases that characterize low mood populations (Williams, 1997). Furthermore, although the number of questions in the diary was kept to a minimum, participants may not have completed the diary appropriately if they experienced a memory when it was inconvenient to note the details, for example while falling asleep or in a group of people. Therefore, diary records may have underrepresented the number of memories participants experienced. Another interesting potential is that participants really did experience fewer memories the second week as a result of normalization processes, for example as a consequence of being asked in a research setting about memories they may have worried were abnormal. This normalisation process may have reduced any attempts at memory suppression. The Ironic Process Theory (Wegner, 1994) maintains that memory suppression paradoxically *increases* the number of intrusive memories experienced. Therefore participants may have experienced fewer memories if they stopped trying to suppress the memory, or ruminated less about having experienced a memory. This possible explanation awaits further investigation, for example with a study that counterbalances the order in which retrospective and diary measures are completed, or that compares the measures in a between-subjects design. In terms of the implications for the current programme of research, it suggests that both measures should continue to be used, when both measures are appropriate, in

case the different methodologies truly are measuring different aspects of involuntary memory and do show a different relationship with cognitive control on a more sensitive task. For the other correlations, the more memories participants reported retrospectively, the more distress they reported. This is contrary to previous research (Starr & Moulds, 2006; Williams & Moulds, 2008b) that found no significant relationship between frequency and distress (measured on an 100 point scale, rather than with the IES). This is interesting as both studies used subjective measures, and is consistent with the idea that although the events reported by high BDI-II participants are not objectively more negative than those reported by low BD-II participants, they are rated as being more negative (Kvavilashvili & Schlagman, 2011). Again, this is supported by the non-traumatic nature of intrusive memories reported by depressed individuals; they reflect non-traumatic types of negative life events, such as interpersonal arguments and relationship break-ups (Brewin et al., 1996b; Moulds & Krans, 2015). The finding that trait rumination correlated with intrusion-related distress supports the idea that both are looking at consequences of the memory (i.e. the tendency to get stuck on a negative memory). Therefore people who tend to ruminate more when feeling sad also report more distress specifically following a memory that was not deliberately recalled.

In conclusion, the current study did not find any clear intrusive memory related deficits on the AX-CPT. The only significant finding was that individuals who recorded a high number of negative involuntary memories in the diary made more errors on long duration trials, suggesting a deficit in proactive control. The next study uses a similar methodology, but extends the focus from intrusive memory to involuntary memory more generally, i.e. without limiting the focus to intrusive or

negative involuntary memories. This wider emphasis stems from the considerable amount of research conducted into involuntary memory, without a specific focus on clinical disorders. This research suggests that involuntary memories are a common feature of memory and cautions against the conceptualization of the cognitive mechanisms underlying intrusive memories as fundamentally maladaptive (Berntsen, 2011; Rasmussen & Bernsten, 2009). These conclusions suggest that before inferences about the role of cognitive deficits in intrusion vulnerability can be drawn, it is important to establish whether individual differences in cognitive control contribute to the overall number of involuntary memories experienced, irrespective of the valence of the memory.

## **Chapter five.**

# **Cognitive control and involuntary memory.**

## **Introduction:**

This chapter will argue that it is important to extend the current research investigating the role of cognitive control in intrusive memory vulnerability to incorporate involuntary memories more generally. This would include memory that comes to mind without being deliberately recalled; the memory could be positive, negative or neutral. Although it has been shown that intrusive memories are experienced by healthy populations (Hauer et al., 2006; Newby & Moulds, 2011a; Verwoerd et al., 2009) and that depressed individuals do experience positive and neutral involuntary memories (Watson et al., 2012), clinically-focused research has predominantly only focused on intrusive memories. This focus has persisted despite considerable empirical and theoretical support for the idea that intrusive memories are not necessarily different to negative involuntary memories (Berntsen, 2010, 2011; Moulds & Krans, 2015; Rasmussen & Bernstein, 2009). For example, no research looking at deficits in cognitive control as a potential vulnerability factor has looked at the wider experience of involuntary memory, beyond using self-report measures of cognitive failures (Kamiya, 2014). The association between intrusive memories and mental health conditions supports an initial emphasis on these negative intrusive memories. It has been shown that intrusive memories, and reactions to intrusive memories, play a part in the maintenance of emotional disorders, for example depression and PTSD (Ehlers, 2010; Newby & Moulds 2011b). Therefore delineating potential vulnerability factors is an important step towards better understanding these memories.

Nevertheless, as discussed in the introductory chapter, there are three main reasons for broadening the emphasis from intrusive to involuntary memory experience. Firstly, as noted above, intrusive memories are not just experienced by people with mental health issues (Hauer et al., 2006; Newby & Moulds, 2011a). Secondly, not all

involuntary memories are negative in valence (Berntsen, 1998; Berntsen & Hall, 2004), and research suggests positive involuntary memories may not be conceptually different from intrusive or negative involuntary memories (Berntsen, 2011; Rasmussen & Bernsten, 2009). Thirdly, in low mood populations, positive memory recall may be associated with a decrease in mood, rather than the increase in mood that healthy individuals report following a positive memory (Joormann & Siemer, 2004; Joormann et al., 2007; Werner-Seidler & Moulds, 2012). These arguments will now be recapped, before the current study is presented.

As discussed in the introduction chapter, non-clinical populations do report experiencing intrusive memories, as measured by the Intrusive Memory Interview (Hackmann et al., 2004). Specifically, Newby and Moulds (2011a) found no significant differences between the number of days on which currently depressed, recovered depressed and never depressed individuals reported intrusive memories. Additionally, numerous studies have used non-clinical samples to investigate characteristics of intrusive memories (Williams & Moulds, 2007c; Williams & Moulds, 2008b) or vulnerability factors (Verwoerd et al., 2008; Verwoerd et al., 2011). Therefore it is apparent that, even though this research is conducted with a clinical emphasis, i.e. to better understand the role these memories play in PTSD or depression, intrusive memories are not just experienced by clinical samples. Despite this, the clinical focus solely on negative memories may implicitly suggest that unrecalled memories are always unwanted or always problematic. However, Berntsen and colleagues' research into involuntary memory as a more general concept instead views involuntary memory as a basic mode of remembering, sharing similar encoding and maintenance features to voluntary memory (Berntsen, 2011). Accordingly,

Berntsen (2011) argues that while involuntary memories can sometimes become problematic, such as the case with intrusive memories studied in the clinical context, the mechanisms underlying these memories are not themselves necessarily purely problematic mechanisms. Furthermore, they argue that these distressing intrusive memories can be accounted for using the same mechanism as more everyday experiences of involuntary memory (Berntsen, 2011). Therefore, while the proportion of positive and negative involuntary memories experienced may change as a function of depressive symptomatology (Rasmussen & Bernsten, 2009), there is little evidence to say intrusive memories are necessarily *conceptually* different to ordinary non-repetitive unrecalled memories (Berntsen, 2011). Their work has shown that involuntary memories are common, although the specific number varies both over time and between individuals (Berntsen, 2011). Indeed, in general samples, involuntary memories are mostly rated as positive in valence (Berntsen, 1998; Berntsen & Hall, 2004; Berntsen & Rubin, 2008). Even in a sample of students meeting criteria for PTSD on the Post-Traumatic Stress Diagnostic (PDS) questionnaire, equal amounts of negative and positive involuntary memories were recorded in the diary, which participants completed open-endedly without time constraints, until they had a total of 50 memories (Berntsen, 2001). Additionally, 78% of the memories recorded did not involve the traumatic event participants had experienced, questioning the idea that involuntary memories primarily consist of special events. Returning to the repetitive element of intrusive memories posited by Kvavilashvili (2014), Berntsen and Rubin (2008) investigated recurrent memories, both positive and negative, in a large Danish population via a telephone survey. Approximately half of the 1,504 participants surveyed said they had experienced a recurrent memory over the past year, the majority (58%) of which were positive or



highly positive. By contrast, only a fifth of the memories were rated to be negative or highly negative. These results suggest that even recurrently experienced memories are not restricted to memories of negative events. The implications from this work are that in some circumstances, the ability to inhibit any involuntary memory (whether positive or negative) may be an important individual difference that determines who will experience a high number of memories they did not deliberately recall. The impact of cognitive control may not depend on the valence of the memory. Existing investigations into the impact of cognitive control on involuntary memories have only used self-report measures of cognitive failures. Nonetheless, Verwoerd and Wessel (2007) and Kamiya (2014) provide initial evidence of a significant positive relationship between frequency of involuntary memories (both positive and negative) and scores on a self-report measure of cognitive failure, as measured by the Cognitive Failures Questionnaire. The questionnaire measures failures in perception, memory and motor functions (Broadbent, Cooper, FitzGerald, & Parkes, 1982). The current study seeks to extend this initial evidence using a task that measures cognitive control.

The third reason for looking at involuntary memory more inclusively is that a positive memory may not always have a positive impact on mood. This suggestion comes from work on voluntary memory recall in low mood populations. Voluntarily recalling a positive memory may be an effective mood regulation strategy for a healthy individual who is experiencing a transient sad mood (Joormann & Siemer, 2004). However, Joormann et al. (2007) demonstrated that, although currently-depressed participants were able to successfully access positive memories, positive memory recall in this group caused a *decrease* in current mood ratings. Never-depressed individuals reported an increase in positive mood, while there was no effect

of positive memory recall on mood in the formerly-depressed participants. Werner-Seidler and Moulds (2012) extended this finding to demonstrate a differential impact of analytical and experiential processing on the effects of positive memory recall on mood. They showed that, whereas currently and recovered-depressed participants induced to an analytical processing mode (e.g. ‘think about the causes, meanings and consequences of what happened’) prior to their positive memory recall demonstrated no change in mood, both groups reported an increase in mood following a concrete induction condition (e.g. ‘play the scene over in your head like you are replaying a movie of how the event unfolded’). These findings demonstrate a parallel with research by Watkins (2004) and Watkins and Teasdale (2004) on analytical and experiential processing styles conducted into negative voluntary memory, discussed in the introduction chapter. This work has demonstrated that analytical thinking (e.g. when the individual focuses on *why* they feel down or depressed) is linked to indices of maladaptive processing in low mood populations, for example, overgeneral memory (Watkins & Teasdale, 2004) and poor problem solving (Watkins & Moulds, 2005). Conversely, encouraging participants to an experiential mode of thinking (e.g. when an individual focuses on *how* they feel) has been shown to reduce overgeneral memory bias and improve problem solving, respectively (Watkins & Moulds, 2005; Watkins & Teasdale, 2004). Although these studies focused on voluntary memory, the findings imply that the detrimental effects of negative intrusive memories on mood may also apply to non-negative involuntary memories. For example, if an individual responds to a positive involuntary memory with an analytical thinking manner (e.g. ‘why aren’t things this good now?’), they may experience a decrease in mood. As a result, these individuals may be similarly motivated to prevent either a negative involuntary memory or a positive involuntary memory coming to mind. Therefore,

assuming that individual differences in cognitive control will only be important for negative memories may be too simplistic. Even when positive or neutral memories have a positive impact on mood, they may still be distracting to the current task. Therefore individual differences in the ability to control these memories may be important in determining whether or not these kinds of memories are commonly experienced. The current study addresses this by extending upon the previous chapter to incorporate a more general investigation of involuntary memory.

The lack of clarity in terminology between the terms intrusive and negative involuntary memory, as highlighted by Kvavilashvili (2014), may also impact studies of intrusive memory and cognitive control. Although the Intrusive Memory Interview explains to participants that an intrusive memory would include a memory of ‘any negative event/circumstance or situation that has actually happened to you’ (Hackmann et al., 2004) it remains unclear whether participants report (or even accurately recall) memories of *all* negative events during this procedure, or whether they only report highly negative, important or repetitive memories. If participants are interpreting the definitions slightly differently, this introduces a degree of subjectivity in cases where the content of the memory is not explicitly defined, for example when memories do not specifically refer to a film-clip or concern one specific past stressful event. This confound is especially problematic in light of the retrospective assessments predominantly used in the intrusive memory literature; an involuntary memory of a negative past event may be experienced only briefly and forgotten if not immediately recorded (Berntsen, 2011; Rasmussen et al., 2014). Likewise, perhaps only highly emotional memories are remembered. Therefore, asking participants about involuntary memories (without using the word ‘intrusive’) may make the

estimates of involuntary memories for negative events more accurate. It is important to establish baseline estimates of involuntary memories, and any link between cognitive control and memory experience, before later turning to a more specific focus on one subsample of involuntary memory.

Frequency of involuntary memories will be assessed using a diary method, as primarily used in the involuntary memory literature (Berntsen, 2001; Berntsen, 2010; Berntsen & Rubin, 2002; Watson et al., 2012). Given the predicted high number of involuntary memories experienced over a week, previous work suggests the frequency can be between 3-5 per day (Berntsen, 1996; Berntsen, 2001), and in light of the suggestion that many of these memories will be forgotten if not recorded immediately (Berntsen, 2011), only the diary method, and not the retrospective ratings method used in the previous chapter, was deemed appropriate for the current research question. To account for the possibility that participants may not completely comply with diary keeping instructions, for example because it is too time consuming, participants will be asked to complete one final questionnaire when they hand their diaries in. This questionnaire will ask participants to estimate the number of memories they experienced but did not record in the diary, whether because they experienced a memory when it was not convenient to record the details, or it was a memory they did not wish to disclose etc. There will therefore be two frequency measures in this study; the diary measure and the summative measure, which equates to the number of memories in the diary plus the number of additional memories indicated on the questionnaire.

### **The present study:**

In summary, the current study explores whether individual differences in cognitive control, as measured by the AX-CPT, are linked to the number of involuntary memories experienced in a non-clinical student and community sample. During the first session, participants will complete the AX-CPT task and two self-report questionnaires; the BDI-II and RRS, because of the traditional focus of intrusive memories in depression. Participants will then keep a diary of any involuntary memories they experience over the next week. One week later, participants will return to hand in their diaries and complete a final questionnaire assessing the number of involuntary memories they experienced but did not record in the diary, before being debriefed. As before, group categorization on all variables (high versus low) will be split around the mean (once again, the mean number of involuntary memories in the diary was higher than the median; mean = 6.4, median = 5 (SD=3.53)). In addition to the mean split analyses of BDI-II scores, the impact of extreme BDI-II scores (low extreme BDI-II < 7, high extreme BDI-II  $\geq 17$ ) on task performance will again be assessed.

### **Predictions:**

#### **1) Overall task:**

As the task was conducted in exactly the same way as the previous study, the overall task data is expected to replicate the previous findings. Therefore, significant main effects of SOA (short, long) and condition (AY, BX and BY) are expected.

Specifically, RTs are predicted to be shorter and error rates lower for long SOA trials, as compared to short SOA trials, as participants have more time to use cue-based information to prepare a response in the long SOA trials. RTs are also predicted to be longer and error rates higher for AY trials as compared to BX and BY trials, as

participants are expected to incorrectly prepare a ‘target’ response following the cue-letter A during the AY trials. The unexpected lack of BX/BY difference in terms of RTs in the previous study awaits replication, but the BX/BY difference is predicted to emerge in the error data, as it did in the previous study.

## **2) Group comparisons:**

It is predicted that cognitive control, as indexed by AX-CPT performance, will be affected by involuntary memory frequency, both diary and summative measures, irrespective of valence of the memory. Individuals experiencing a higher number of memories are expected to show less proactive control and consequently more reactive control, indexed through impaired BX performance and better AY performance, than individuals experiencing a low number of involuntary memories, who are expected to show impaired AY performance but better BX performance. Neither the previous study nor Msetfi et al. (2009) found task performance to be affected by rumination, therefore, although rumination will be measured as a means of assessing the potential detrimental impact of the consequences of the memory, task performance is not predicted to be impacted by trait rumination. Given the contradictory results of the previous chapter and Msetfi et al. (2009) it is unclear whether task performance will be affected by depressive symptomatology, as measured by the BDI-II.

## **3) Correlations between involuntary memories and questionnaires:**

There is predicted to be a significant correlation between the diary and summative measures of involuntary memories, as both measures are assessing involuntary memories experienced over the same time period. Based on a wealth of existing research citing the role of rumination in depression (Nolen-Hoeksema, 1991;

Spasojević & Alloy, 2001), including the significant positive relationship found in the previous chapter, the correlation between RRS and BDI-II scores is also expected to be significant. It is unclear whether there will be significant correlations between the frequency measures of involuntary memories and the BDI-II or the RRS.

#### **4) Valence of involuntary memories in relation to depressive symptomatology:**

Based on the concept of involuntary memory as a basic mode of remembering (Berntsen, 2011) and specific work by Kvavilashvili and Schlagman (2011) and Watson et al. (2012) looking at involuntary memories in dysphoric and depressed samples, high BDI-II participants are predicted to record both positive and negative involuntary memories in the diary. The proportion of extremely positive and extremely negative memories will then be calculated. No research has looked at the relationship between the proportion of positive and negative memories reported in daily life as a function of BDI-II score. In their discussion section, Watson et al. (2012) report the percentages of positive (50%), negative (34%) and neutral (15%) memories reported by their currently depressed sample, but not the percentages reported by the never depressed group so no comparisons between the two experiences can be made. Consequently, it is unclear whether there will be a significant correlation between the proportion of positive and negative memories and BDI-II scores.

#### **Methods:**

##### *Participants:*

The study was granted ethical approval by the University Teaching and Research Ethics Committee (UTREC). Participants (students and members of the community) were recruited through the Psychology & Neuroscience departmental SONA system

and via adverts posted on the University memo bulletins. To meet study eligibility participants had had to have recently experienced involuntary memories and speak English fluently. In total, 31 participants were recruited. One participant was excluded as they reported a diary frequency of memories 3 SDs above the mean (frequency = 37, details below). Consequently, 30 participants remained for the analysis (26 female, 4 male, age range 17-35). No other data points were more than 3 SDs above the mean, therefore no other data were excluded. Power analysis revealed that a sample size of 36 would be required to detect a medium effect size at a 95% confidence interval using a .05 criterion of statistical significance. Therefore the sample size actually used was very small. Participants were reimbursed £10 total for their participation.

*AX-Continuous Performance Task (AX-CPT):*

The task was presented exactly as in the previous study. See the previous chapter for details.



### *Procedure:*

After providing informed consent, participants completed the AX-CPT task (lasting approximately 30 minutes), followed by the BDI-II and RRS in a randomized order. Participants were given the definition and an example of an involuntary memory and asked to provide an example to ensure they had fully understood the definition. Following this, participants were given the paper diaries and the instructions for the next week. Seven days later participants returned to the research laboratory to hand in their diaries and fill out the final questionnaire. Finally participants were debriefed and reimbursed £10 for their time.

### **Results:**

As in the previous study, the overall task data will be presented first. Then the groups will be compared on task performance. For the ‘target’ trials this will comprise of a 1-way repeated-measures ANOVA with the within-subjects factor SOA (short, long) and the between-subjects factor; specifically using the diary measure, the summative measure, the RRS and the BDI-II splits. For the ‘non-target’ trials, this will comprise of a repeated-measures ANOVA with the within-subjects factors SOA (short, long) and condition (AY, BX, BY) and the between-subjects factor. For the between-group analyses only effects involving the factor group will be reported. As for the previous AX-CPT study, Bonferroni corrections were made to the post-hoc comparisons only.

#### **1) Overall Task Data:**

Mean RTs and error rates for all trial types are displayed in Figure 5.1, split by short (700 ms) and long (4700 ms) SOA trials.

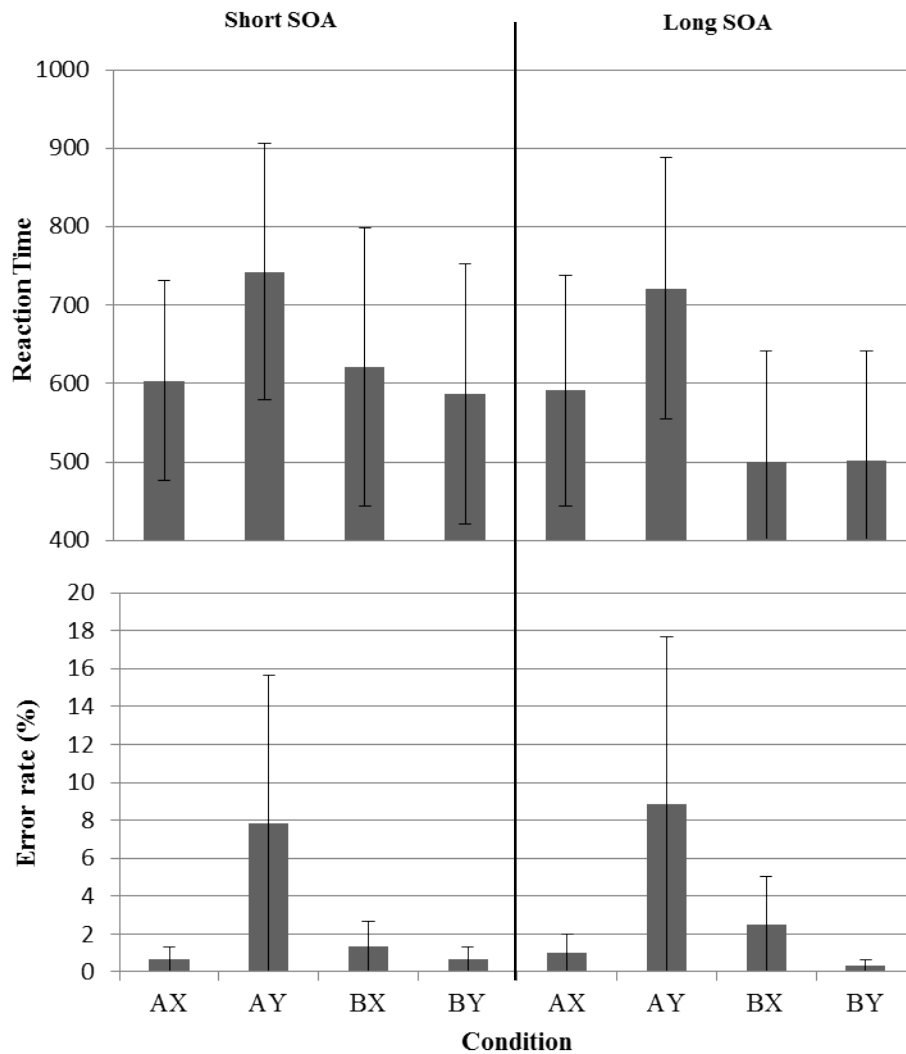


Figure 5.1. Mean RTs and error rates (with standard error bars) for each trial type, split by the two SOA trials (short versus long).

**i) ‘Target’ (AX) trials:**

**RTs:** The main effect of SOA was not significant  $F(1, 29) = 1.36, p > .05$ .

**Error rates:** Kolmogorov-Smirnov tests revealed that the error data were not normally distributed,  $Ds(30) > 0.23, ps < .01$ . The data were therefore arcsine transformed and submitted to a repeated-measures ANOVA. As for the previous

study, the means reported in the text and shown in the figures are based on the original data. The main effect of SOA was not significant,  $F(1, 29) = 1.14$ ,  $p > .05$ .

**ii) ‘Non-target’ (AY, BX, BY) trials:**

**RTs:** There was a significant main effect of SOA,  $F(1, 29) = 37.18$ ,  $p = .01$ , partial  $\eta^2 = .56$ . RTs were significantly faster for the long SOA (mean = 575 ms, SD = 25.40) than for the short SOA (mean = 650 ms, SD = 29.36). There was also a significant main effect of condition  $F(2, 58) = 108.74$ ,  $p = .01$ , partial  $\eta^2 = .79$ . Pair-wise comparisons were then conducted. After Bonferroni corrections, the  $p$  value needed to be smaller than .02 to reach statistical significance. These comparisons revealed this reflected slower RTs for AY trials (mean = 732 ms, SD = 29.48) compared to both BX (mean = 561 ms, SD = 27.50) and BY trials (mean = 545 ms, SD = 26.82), both  $F_s > 118.18$ ,  $p_s < .02$ , both partial  $\eta^2_s > .80$ . BX and BY trials did not differ significantly from each other,  $F(1, 29) = 3.19$ ,  $p > .02$ . The condition x SOA interaction was also significant,  $F(2, 58) = 14.09$ ,  $p = .01$ , partial  $\eta^2 = .34$ . There was a significant difference between the two SOAs for BX (120 ms) and BY (85 ms) trials, both  $F_s > 28.30$ , both  $p_s < .01$ , both partial  $\eta^2 > .50$ . This difference was not significant for AY trials (21ms),  $F(1, 29) = 2.64$ ,  $p > .05$ .

**Error rates:** The main effect of SOA was not significant,  $F(1, 29) = 0.43$ ,  $p > .05$ . The main effect of condition was significant,  $F(2, 58) = 36.99$ ,  $p = .01$ , partial  $\eta^2 = .56$ . Pair-wise comparisons revealed this reflected a significantly higher percentage of errors made to AY (mean = 8.33%, SD = 1.3) than to both BX (mean = 1.92%, SD = .50) and BY trials (mean = 0.50%, SD = .22),  $F_s > 31.04$ ,  $p_s < .01$ , partial  $\eta^2 = .46$ . Significantly more errors were also made to BX trials than BY trials,  $F(1, 29) = 9.07$ ,

$p = .01$ , partial  $\eta^2 = .25$ . The SOA x condition interaction was not significant,  $F(2, 58) = 0.59$ ,  $p > .05$ .

*Task summary:* In summary, the overall task data replicates the findings of the previous study. The effect of SOA (faster RTs on ‘non-target’ trials on long SOA trials) supports the use of proactive control in the task; participants used the cue information to prepare a response. The effects of condition that were found in the previous study were also replicated; participants were slower and made more errors on AY trials as compared to BX and BY trials. This again demonstrates proactive control, i.e. demonstrates that participants were also to prepare a response after the cue-letter, and maintain this information over both SOAs. As found previously, participants also made more errors to BX compared to BY trials (as previously found, error rates were low: 0.83% for ‘target’ trials, 3.58% for ‘non-target’ trials), but RTs did not show this BX/BY difference. The differential impact of the SOA on BX/BY trials as compared to AY trials also replicates results from the previous study; there was only a significant difference between the SOAs for B-letter trials when participants could fully prepare a ‘non-target’ response and benefit more for the longer SOA.

## **2) Group comparisons:**

Table 5.1 overleaf displays the descriptive statistics for each of the questionnaires. It also explains the composition of the high and low groups based on mean splits.

Table 5.1

*Means and standard deviations (SD) on the self-report scales, and the composition of the groups based on mean splits.*

Variable	Mean	S.D.	Group split value	N high	N low
Diary	6.4	3.53	$\geq 6$	13	17
Summative	12	7.89	$\geq 12$	12	18
RRS	46.73	8.08	$\geq 47$	15	15
BDI-II	9.23	5.65	$\geq 9$	16	14
Extreme BDI-II	9.21	7.04	High $\geq 17$ , low $< 7$	5	9

### i) ‘Target’ (AX) trials:

Tables 5.2 and 5.3 below display the *F*-values for ‘target’ trials for each between-group variable, for reaction times and error rates respectively. There were two significant between-group differences in the RT data, involving BDI-II group and the extreme BDI-II group. No effects reached significance in the error data. Significant *F*-values are presented in bold, and the figures for these significant effects are presented below the table.

Table 5.2

*F*-values for **reaction times** to ‘target’ trials, for each between-group variable. Significant *F*-values are presented in bold.

	Diary	Summative	RRS	BDI-II	Extreme BDI-II
Group	0.19	1.04	1.73	1.00	<b>7.61*</b>
Group x SOA	0.37	0.11	0.56	<b>4.52*</b>	3.22

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$

The BDI-II x SOA interaction was significant,  $F(1,28) = 4.52$ ,  $p = .04$ , partial  $\eta^2 = .14$ . For the high BDI-II group, target responses were significantly slower for short SOA trials (636 ms,  $SD = 27.8$ ) as compared to long SOA trials (604 ms,  $SD = 30.8$ ) SOA,  $F(1, 15) = 5.84$ ,  $p = .03$ , partial  $\eta^2 = .28$ . However, there was no difference

between the SOAs for the low BDI-II group,  $F(1, 13) = 0.48$ ,  $p > .05$  (mean short = 567 ms,  $SD = 36.9$ , mean long = 576 ms,  $SD = 46.4$ ). This is displayed in Figure 5.2 below.

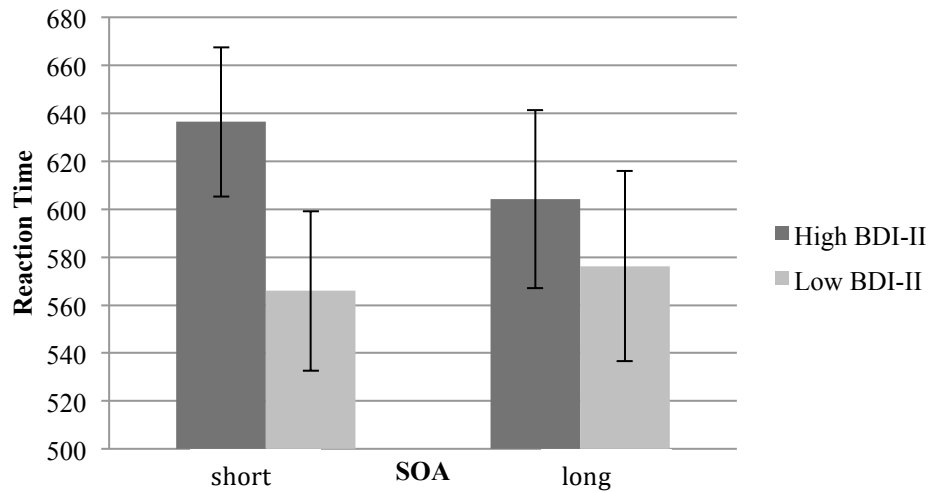


Figure 5.2. Mean RTs (with standard error bars) over the two SOAs and split by high and low BDI-II group.

The main effect of extreme BDI-II was significant,  $F(1, 12) = 7.60$ ,  $p = .02$ , partial  $\eta^2 = .39$ . Participants in the high extreme BDI-II group generally responded slower (mean = 677 ms,  $SD = 45.31$ ) than participants in the low extreme BDI-II group (mean = 521 ms,  $SD = 33.77$ ). This is displayed in Figure 5.3 overleaf.

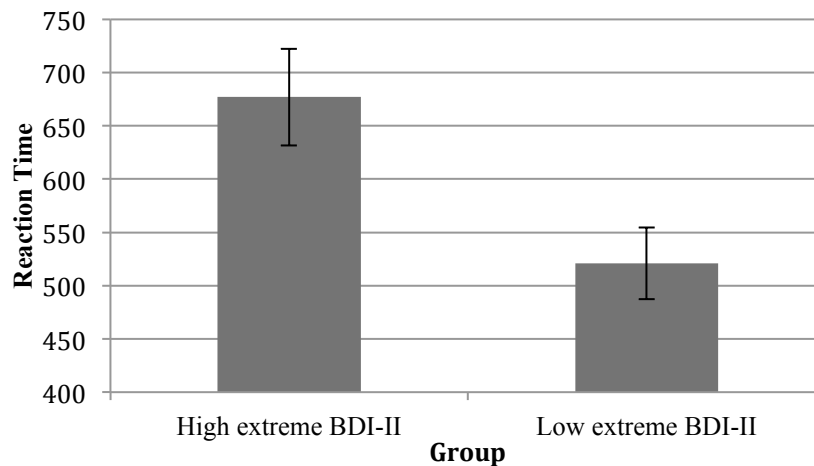


Figure 5.3. Mean RTs (with standard error bars) to ‘target’ trials, split by high and low extreme BDI-II group.

Table 5.3

*F-values for **error rates** to ‘target’ trials, for each between-group variable. No effects reached significance.*

	Diary	Summative	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	1.40	0.01	0.02	1.74	0.01
<b>Group x SOA</b>	3.42	0.40	2.11	0.63	1.27

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$*

## ii) ‘Non-target’ (AY, BX, BY) trials:

Tables 5.4 and 5.5 display the F-values for ‘non-target’ trials for each between-group comparison. In the extreme BDI-II group there was a speed-accuracy trade-off; high extreme BDI-II participants responded slower, but made fewer errors, than low extreme BDI-II participants. This demonstrated that the high extreme BDI-II group was more conservative in their responses. In the error data, there was an effect in the RRS group, where high ruminators made more errors in long SOA trials as compared to short SOA trials. Significant F-values are presented in bold, and the figures for these significant effects are presented below the table.

Table 5.4

*F-values for **reaction times** to ‘non-target’ trials, for each between-group variable. Significant *F*-values are presented in bold.*

	Diary	Summative	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.25	0.77	0.81	1.94	<b>17.97**</b>
<b>Group x condition</b>	0.07	0.41	0.17	0.11	0.21
<b>Group x SOA</b>	0.55	1.41	1.82	0.17	0.39
<b>Group x condition x SOA</b>	0.13	0.14	0.56	0.23	1.27

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$

The main effect of extreme BDI-II group was significant,  $F(1, 12) = 17.97$ ,  $p = .01$ , partial  $\eta^2 = .60$ . The mean RT in the low extreme BDI-II group was faster (mean = 526 ms, SD = 31.59) than the high extreme BDI-II group (mean = 744 ms, SD = 42.38). This is displayed in Figure 5.4 below. However, as this appears to be a difference in speed accuracy trade-off as the high extreme BDI-II group made significantly fewer errors than the low extreme BDI-II group (see error data below, represented in Figure 5.5).

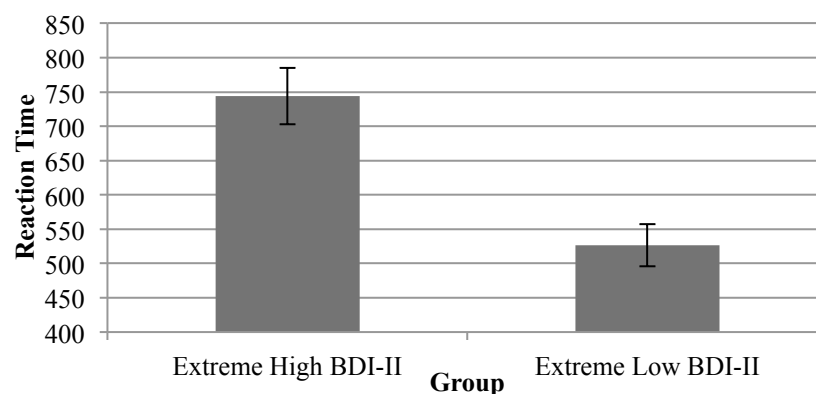


Figure 5.4. Mean RTs (with standard error) to ‘non-target’ trials, split by high versus low extreme BDI-II group.

As mentioned above, this finding reflects that the high extreme BDI-II group were more conservative, as they made fewer errors than the low extreme BDI-II group.



There was a significant main effect of extreme BDI-II group:  $F(1, 12) = 10.83$ ,  $p = .01$ , partial  $\eta^2 = .47$ . The mean percentage of errors made was higher in the extreme low BDI-II group (mean = 5.37%, SD = 0.81) than in the extreme high BDI-II group (mean = 1.83%, SD = 1.08). This effect is displayed in Figure 5.5 below.

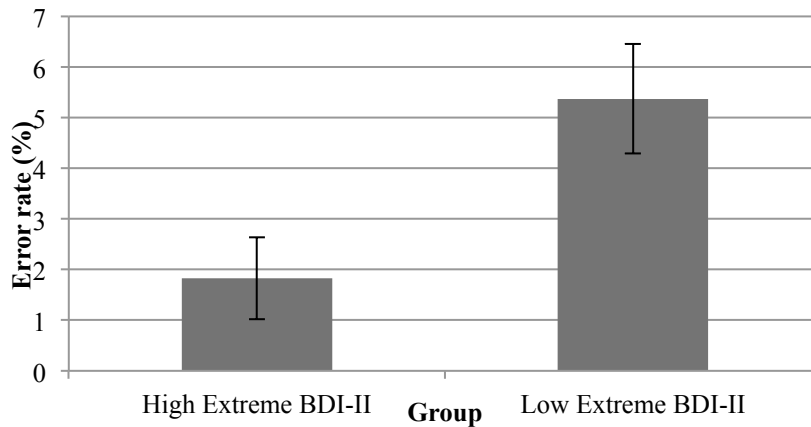


Figure 5.5. Mean error rates (with standard error bars) to ‘non-target’ trials, over the two SOAs and split by high and low extreme BDI-II group.

Table 5.5

*F-values for **error rates** to ‘non-target’ trials, for each between-group variable. Significant F-values are presented in bold.*

	Diary	Summative	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.62	0.71	2.45	0.69	<b>10.83**</b>
<b>Group x condition</b>	0.63	0.27	2.78 (*)	0.32	3.39 (*)
<b>Group x SOA</b>	0.11	0.10	<b>7.66 *</b>	0.71	3.52 (*)
<b>Group x condition x SOA</b>	0.88	0.59	0.99	0.99	0.49

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$

The RRS group x SOA interaction was significant,  $F(1, 28) = 7.66$ ,  $p = .01$ , partial  $\eta^2 = .22$ . Participants in the high RRS group made significantly more errors on the long SOA trials (mean = 5.57%, SD = .93) as compared to the short (mean = 3.11%, SD = .74),  $F(1, 14) = 4.39$ ,  $p = .05$ , partial  $\eta^2 = .24$ . The difference between the short (mean = 2.22%, SD = .93) and long (mean = 3.44%, SD = 0.73) SOAs was not

significant for the low RRS group,  $F(1, 15) = 2.66$ ,  $p > .05$ . This effect is displayed in Figure 5.6 below.

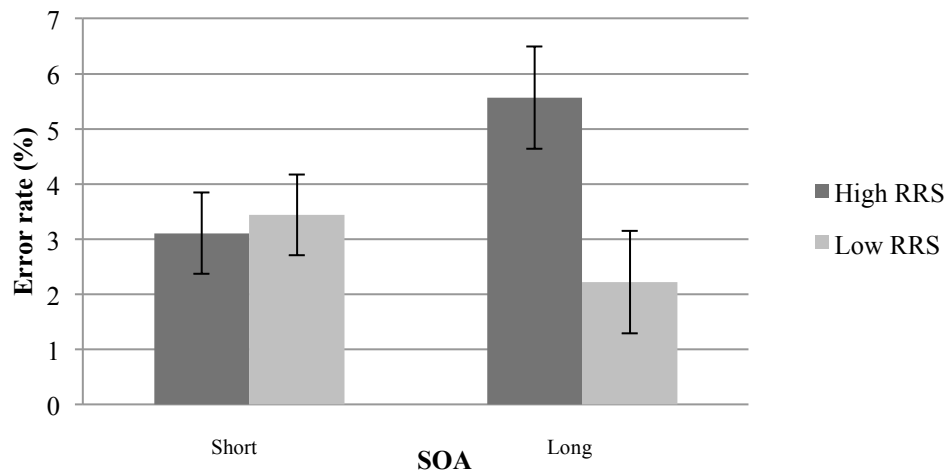


Figure 5.6. Mean error rates (with standard error bars) made to ‘non-target’ trials, over the two SOA and split by high and low RRS group.

*Group comparisons summary:* Contrary to predictions, there was no link between the frequency of involuntary memories participants reported and task performance, either in terms of the diary measure or the summative measure. On the consequences of the memory measures, only a group effect of rumination emerged in the error data for ‘non-target’ trials. Specifically, high ruminators made significantly more errors to ‘non-target’ trials in the long SOA trials, while low ruminators made more errors in the short SOA ‘non-targets’ trials, although this difference was not significant in the low rumination group. This is consistent with the idea that engaging in rumination impairs the ability to maintain context information over time (Braver, 2012). The other group differences that emerged were in relation to depressive symptomatology. The high BDI-II group responded significantly slower to ‘target’ trials with a short SOA compared to ‘target’ trials with a long SOA, but this effect was slightly reserved,

but not significantly so, in the low BDI-II group. This, contrary to predictions, suggests a slight deficit in context maintenance in the low BDI-II group.

In terms of the extreme BDI-II comparisons, the low extreme BDI-II group responded faster (to ‘target’ and ‘non-target’ trials), but made more errors (in ‘non-target’ trials) than the extreme high BDI-II group. This therefore reflects a difference in speed-accuracy trade-off, rather than any difference in context processing or context maintenance abilities.

### **3) Correlations between involuntary memories and questionnaires:**

Table 5.6 is a correlation matrix displaying the relationship between the self-report measures. There was a significant correlation between the diary and summative measures. This is consistent with predictions, because the measures both assess the number of memories experienced over the same time point. It also supports the validity of the diary measure, as the participants who had the most memories in their diaries still had the most memories when memories that were not recorded were also included. The significant correlation between RRS and BDI-II replicates a consistent finding in the depression literature, i.e. that low mood is associated with ruminative processes (Nolen-Hoeksema, 1991; Treynor et al., 2003; Williams & Moulds, 2008b) and replicates results of the previous chapter. Significant correlations are presented in Figure 5.7.

Table 5.6

*A correlation matrix for the questionnaire measures. Significant correlations are displayed in Figure 5.8.*

	Measure	1. Diary	2. Summative	3. RRS
1.	Diary			
2.	Summative	0.61 **		
3.	RRS	0.14	0.02	
4.	BDI-II	0.26	0.15	0.44 *

*\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$ , two-tailed*

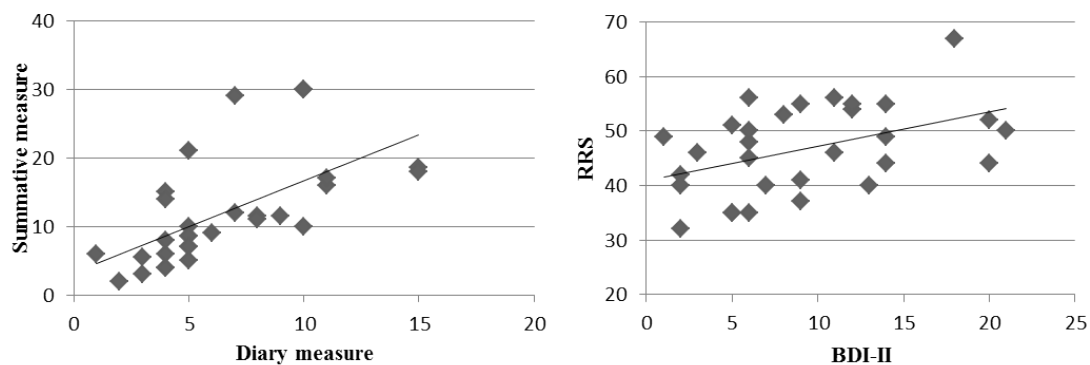


Figure 5.7. Displaying the significant correlations found in the self-report measures.

#### 4) Valence of the involuntary memories:

The correlation between mean valence of the involuntary memories and BDI-II was not significant,  $r(30) = .13$ ,  $p > .05$ , two-tailed. To avoid the possibility that positive and negative memory ratings were just cancelling each other out, the relationship between extremely negative (memories rated a 0 or a 1 on the 5-point scale) or extremely positive (memories rated a 4 or a 5) and mood was then explored. This was done by calculating the number of extremely negative and extremely positive memories experienced, as a proportion of total memories experienced. For example, if one participant reported 4 memories in total, 2 of which were rated a 0 out of 5 and 2 of which were rated a 5 out of 5, the proportion of memories would be 0.5 negative and 0.5 positive respectively. The correlations between these proportions and BDI-II scores were then calculated.

The correlation between extremely negative memories and BDI-II score was not significant,  $r(30) = -.14$ ,  $p > .05$ , two-tailed. The correlation between extremely positive memories and BDI-II score was also not significant,  $r(30) = -.02$ ,  $p > .05$ , two-tailed. These results suggest that, in a general student and community sample, experiences of involuntary memories do not vary systematically as a function of depressive symptomatology, as measured by the BDI-II.

### **Discussion:**

The current study investigated a potential link between individual differences in cognitive control and the number of involuntary memories experienced. This was an extension of previous research, which has looked at deficits in cognitive control and the experience of intrusive and negative involuntary memories. Specifically, it has previously been demonstrated that individual differences in proactive interference are associated with intrusive memory experience (Verwoerd et al., 2009; Verwoerd et al., 2011). In conjunction with the previous chapter, the present study aimed to determine if deficits would be found on the AX-CPT, which is a more basic measure of cognitive control than the tasks used in this previous research looking at proactive interference. Importantly, the task is based on the Dual Mechanisms of Control (DMC) theory which distinguishes between proactive and reactive modes of control (Braver et al., 2007). The DMC highlights the importance of potential shifts between the two processing modes as a function of individual differences, or differences in task specific parameters (Braver, 2012; Braver et al., 2007; Speer et al., 2003).

Therefore using the DMC is an important addition to existing research into potential mechanisms underlying the heightened numbers of involuntary memories. Another specific goal of this study was to look more broadly at involuntary remembering, incorporating both positive and negative memories than the previous sole focus on

negative intrusive memories. While the clinical literature has focused heavily on these intrusive memories (Newby & Moulds, 2011c, 2011d; Williams & Moulds, 2008b), Berntsen and colleagues' extensive research into involuntary memory suggests that memories for traumatic or highly stressful events are not fundamentally different to more everyday types of involuntary memories (Berntsen, 2011; Berntsen & Rubin, 2008). Therefore, before conclusions can be drawn about the role of cognitive control in *intrusive* memory experience, it is important to establish whether individual differences in cognitive control also contribute to the number of involuntary memories experienced. This has not previously been addressed, beyond self-report measures of cognitive failures (Kamiya, 2014, Verwoerd & Wessel, 2007). These studies did provide initial evidence that there is a link between individual differences, highlighting that higher levels of cognitive failure were associated with higher numbers of involuntary memories (of all valences). However, this relationship needs to be further investigated using cognitive tasks. Another important reason to extend existing research was the finding that positive voluntary memory recall can be accompanied by a decrease in mood in dysphoric or depressed populations (Joormann & Siemer, 2004; Joormann et al., 2007). Therefore, the ability to inhibit an unrecalled memory may not be limited to emotionally negative memories.

As found in the previous chapter, only some of the task predictions were met. For example, RTs were significantly faster for both BX and BY trials than for AY trials, suggesting that participants used the cue letter B to prepare a 'non-target' response. In addition, there was no significant difference in RTs between BX and BY trials, although again more errors were made to BX trials as compared to BY trials. Once more, the overall error rate to 'non-target' trials was low (3.58%), which meant that

the task might not have been sensitive enough to subsequently uncover any potential group differences in BX/BY performance. The lack of RT difference between BX and BY trials suggests that participants were always able to prepare the appropriate ‘non-target’ response following the cue-letter B, without needing to wait for additional information from the letters X or the Y. Importantly, this cue-information was adequately maintained over both SOA conditions, rather than decaying in the long SOA condition. This finding suggests that there was no need for participants to engage in any reactive (i.e. target-letter) processing. As in the previous chapter, the long SOA was shorter than that used in previous studies (Msetfi et al., 2009) and reflects a substantial limitation of the current design. In contrast, the expectancy violation leading to slower RTs on the AY trials was similar across the two SOAs, rather than being larger in the short SOA. This again suggests participants adequately maintained the context provided by the cue-letter (in this case the letter A) over both SOA conditions. These problems limit the conclusions of the task, as by not tapping into reactive control, the task did not address the flexible nature of cognition inherent in the DMC framework of cognitive control (Braver, 2012; Braver et al., 2007). This limitation will be addressed in the subsequent chapter by using a more extreme difference between the short and long SOAs trials, and to bring the SOAs into line with existing research (Braver et al., 2001; Msetfi et al., 2009).

In terms of the group comparisons, no differences in task performance were found between individuals who experienced a high or a low number of involuntary memories, using either the diary or summative frequency measures. These findings call into question the idea that some people regularly experience unrecalled memories as a result of fundamental deficits in their ability to regulate cognitive control (Bomyea, Amir, & Lang, 2012; Verwoerd et al., 2011), in this case specifically

context representation and context maintenance. These findings are consistent with the previous study that looked only at intrusive memories, which only found an error effect in the diary measure, but extends this lack of deficit to all types of involuntary memories. Importantly, like the current study, existing research into underlying deficits in cognitive control has used non-clinical samples as a first step towards establishing the potential role of cognitive control in intrusion vulnerability. Therefore it seems that the lack of findings in the current study are not simply attributable to the sample used.

In light of the highlighted difficulties of measuring involuntary memories (Rasmussen et al., 2014), it is interesting to look at the relationship between the two frequency measures. The mean number of additional memories reported on the final questionnaire was 5.52 (SD = 6.30), and the summative measure of involuntary memories was significantly higher than the number of memories in the diary, mean = 4.43 (SD = 4.01),  $t(30) = -4.70$ ,  $p = .01$ . This suggests this extra questionnaire was useful, as not all involuntary memories were covered by the diary measure. However, interestingly, there was a significant correlation between the measures; individuals reporting higher number of memories in the diary also reported a higher number of memories overall. This suggests that both measures are assessing similar experiences of involuntary remembering, even if not all memories are recorded in the diary. Consequently, the lack of group difference in cognitive control on either frequency measure suggests it is not simply the case that the diary method is not assessing the true frequency of involuntary memories. This is an interesting finding in the context of the suggestion made Verwoerd et al. (2011) that the number of diary recordings may reflect the ability to keep the goal of remembering to record memories in the



diary active. Employing the second, shorter, retrospective questionnaire may somewhat counteract this potential confound, as memories that participants forgot to report may still be included. However, it is important to note that the overall number of memories reported by participants was still low, as compared to other investigations of involuntary memory (Berntsen, 1996; Berntsen, 2001; Finnbogadottir & Berntsen, 2013; Schlagman & Kvavilashvili, 2008). This may reflect participants' lack of motivation to complete the diary properly. This is supported by work by Rasmussen, Ramsgaard, and Berntsen (2015) who found that frequency records were higher for frequency estimates gathered by a mechanical counter, as compared to memories recorded on a smartphone. As a result, it would be useful for future work to test whether using a mechanical counter or a mobile smartphone recording technology would uncover deficits in cognitive control in relation to intrusive or involuntary memory experience.

In addition to memory frequency, the impact of trait rumination on task performance was investigated. This was to account for the idea that it may not be the involuntary memory per se that impacts well-being, but the consequences and the way individuals react to the memory that is important. For example, some people may be more prone to getting stuck on the memory, potentially mirroring the demonstrated importance of appraisals individuals assign to their intrusive memories (Starr & Moulds, 2006; Williams & Moulds, 2008b). In the context of the DMC, it has been suggested that ruminative processes will act as task-irrelevant thoughts and reduce the ability to maintain context overtime (Braver, 2012). However, consistent with the previous study, there was no difference in reaction times between high and low trait ruminators. In the error data, the high rumination group did indeed make a higher

percentage of errors in the long SOA ‘non-target’ trials, in comparison to the low rumination group who made a higher percentage of errors in the short SOA ‘non-target’ trials. This is consistent with the suggestion made by Braver (2012). However, given the low overall number of errors on the ‘non-target’ trials (3.58%), this finding should be interpreted with caution. Nonetheless, it does provide initial evidence that proactive processes, specifically context maintenance over a long duration period, are impaired in high trait ruminators. In turn, this may indicate that individuals who suffer more from their intrusive memories have a deficit in proactive control.

The impact of depressive symptomatology, as measured by the BDI-II, on task performance was also investigated. This was done using both the traditional mean split categorization, and looking only at the extreme BDI-II scores. Contrary to previous research using the AX-CPT (Msetfi et al., 2009) but not the previous study (chapter four), there was no overall deficit as a function of high BDI-II. In fact, on ‘target’ trials, the high BDI-II group actually benefited more from the long SOA than the low BDI-II group in terms of reaction time performance. The other BDI-II related differences in task performance were on the extreme categorization, and reflected a difference in speed accuracy trade-off. Specifically, the high extreme BDI-II group was more conservative in their responses (i.e. they were slower, but made fewer errors). Previously Msetfi et al. (2009) demonstrated that high BDI-II participants were selectively impaired in context maintenance, i.e. selectively made more errors on BX trials in long SOA trials. As highlighted in the discussion section of the previous chapter, there are a variety of methodological differences between this task and the one used by Msetfi et al. (2009) that may account for the different findings; again, the relatively short long SOA in this work as compared to existing research is

problematic. On the other hand, as discussed in the previous chapter, the current lack of proactive impairment in relation to symptoms of low mood is consistent with Saunders and Jentsch (2014). They found no depressive-related proactive impairments in classic and emotional Stroop tasks, which they assessed by manipulating speed-accuracy instructions. In this design, the ability to modify behaviour based on the instruction, specifically performing slower but making fewer errors and vice versa, is the index of proactive control. Interestingly, the same study only found depressive-related deficits in reactive control, indexed by the effect of conflict on subsequent trial performance, on the emotional, and not the classic, Stroop task. This highlights the importance of looking at performance on emotional tasks to assess cognitive control, which will be addressed in the subsequent chapter.

The current study also investigated characteristics of the involuntary memories recorded in the diary as a function of depressive symptomatology; a question that has not received a great deal of research attention (Watson et al., 2012). Firstly, there was no significant correlation between BDI-II scores and the number of memories recorded, as well as no significant correlation between BDI-II score and the mean valence of the memories. These findings are as predicted by Berntsen and colleagues' research into involuntary memory, which concludes that involuntary memories are a common feature of memory, in both healthy and disordered cognition (Berntsen, 2010; Rubin et al., 2008). Outside of a focus of repetitive involuntary memories of negative events, existing research has shown that involuntary memories are not restricted to the recall of special or traumatic events (Berntsen, 2001), are commonly experienced by healthy individuals (Berntsen, 1996, 2010), and low mood and clinically depressed individuals experience both positive and negative involuntary

memories (Kvavilashvili & Schlagman, 2011; Watson et al., 2012) . Therefore, these non-significant correlations are not surprising. As the valence of the memories was rated by participants themselves in the current study (rather than consisting of objective ratings), these results do contrast with Kvavilashvili and Schlagman (2011) who found that dysphoric participants rated their memories as being more negative than non-dysphoric participants. It would be useful to extend the current investigation to specifically recruit dysphoric participants, versus just looking at BDI-II data continuously in a student sample, to investigate this further. The comparison of voluntary and involuntary memories conducted by Watson et al. (2012) suggests that, irrespective of the mode of retrieval (i.e. voluntary or involuntary), clinically depressed participants report more negative memories, stronger emotional reactions to the memories, and higher levels of rumination and avoidance than never-depressed individuals. This was not supported on a continuous scale of depressive symptomatology in a non-clinical sample, and this is important for future research to investigate further.

In the meantime, these non-significant correlations support the idea that a sole focus on intrusive memories in the clinical literature is unjustified, as it is not examining the full range of involuntary memories experienced by depressed participants. As highlighted by Kvavilashvili and Schlagman (2011), it is important to investigate ‘everyday’ negative involuntary memories experienced in low mood, as they are likely to impact mood. For example, if dysphoric individuals do in fact experience frequent negative involuntary memories, and involuntary memories do have a heightened detrimental impact on mood (Berntsen, 1998; Berntsen & Hall, 2004; Watson et al., 2012), then this could start a vicious cycle of an increased number of

involuntary memories and further decreases in mood (Kvavilashvili & Schlagman, 2011). In addition, Watson et al. (2012) argues that, in light of the finding that intrusive memories represent only some of the involuntary memories low mood samples experience, we should be looking at general involuntary memory in depressed participants in order to better understand the role of intrusive memories in depression. This statement supports the extension of the existing intrusive memory vulnerability research; it was important to establish any potential link between deficits in cognitive control and involuntary memory experience.

Along with the aforementioned adjustments to the SOAs, the subsequent study will address the possibility that the lack of deficits in cognitive control stem from the unvalenced stimuli used in the task. This consideration stems from research looking at cognitive control and low mood, which has demonstrated that dysphoric and depressed participants are impaired on tasks which require the processing of emotionally negative information (Joormann, 2004; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005). The next study will also return to a sole focus on intrusive memories, partly due to the potential limitations of assessing involuntary memories, and also since the research that has previous found a link between deficits in cognitive control was looking exclusively at intrusive memories. This may make the task more sensitive to individual differences in cognitive control. However, none of this existing research has looked at performance on emotional tasks. In light of the limitations of the AX-CPT task, the subsequent study will additionally look at performance on the emotional Stroop as a different means of assessing proactive and reactive control, to ensure the lack of clear findings are not just an artefact of the AX-CPT.

## **Chapter six.**

# **Emotional cognitive control and intrusive memories.**

## **Introduction:**

The study presented in this chapter will explore potential cognitive control impairments in individuals who experience a high number of intrusive memories, using emotional measures of cognitive control. The use of emotional tasks is an important extension of the studies presented in the previous two chapters, as the lack of intrusion related-deficits that were found may be a result of the non-valenced material used. The rationale for this suggestion comes from the existing literature looking at cognitive control and depression. Specifically, Gotlib and Joormann (2010) and Kircanski, Joormann, and Gotlib (2012) conclude that depression is characterized by the elaboration of negative material, as well as difficulty disengaging from this negative material. Therefore, depressive-related deficits in cognitive control most consistently emerge when the task requires the processing of emotional information (Goeleven, De Raedt, Baert, & Koster, 2006; Joormann & Gotlib, 2008; Joormann & Siemer, 2004; Koster et al., 2005). Given the association between intrusive memories and depressive symptomatology (Kuyken & Brewin, 1994; Newby & Moulds, 2010, 2011b), and the emotionality of intrusive memories, i.e. that they are a memory of a negative distressing event, it is important to investigate whether the importance of emotional stimuli in uncovering cognitive deficits also applies to the experience of intrusive memories. This may account for the lack of intrusive memory-related deficits in cognitive control in the previous chapters. Therefore, the tasks in this chapter investigate the impact of irrelevant emotional information (both positive and negative) on performance in two emotional cognitive control tasks. Emotional variants of the Stroop and AX-CPT tasks will be used. The emotional Stroop task is used to address some of the previous issues of the AX-CPT. The key question is whether people experiencing a high number of intrusive memories are differentially

affected by the irrelevant emotional material than people who experience fewer intrusive memories. No previous research has used affective cognitive tasks to explore the question of intrusive memory vulnerability. As in chapter four, indices of both intrusive and negative involuntary memories will be collected. Although both these types of memories will be referred to as spontaneous or intrusive memories during the experimental procedure, the data will be analysed using criteria provided by Kvavilashvili (2014), who criticizes the ambiguity about which type of memory is being studied. Specifically, the Intrusive Memory Interview (Hackmann et al., 2004) will be used to provide a retrospective measure of the number of intrusive memories. The retrospective measure 1 (retro 1) will consist of the number of memories experienced in relation to the same event (a traditionally defined ‘repetitive’ intrusive memory). In addition, the retrospective measure 2 (retro 2) will consist of the total number of negative involuntary memories experienced over the past week and reported during the interview. As in the previous two studies, participants will also keep a diary of any negative involuntary memories experienced over the 7-day period after the study, another measure of negative involuntary memories. This thorough assessment of memory experience is also consistent with the argument presented throughout the thesis, namely that intrusive memories do not necessarily conceptually differ from other forms of involuntary memories (Berntsen, 2011), and therefore investigations into underlying cognitive deficits need to consider a wider focus of memory experiences. Nevertheless, a cautious approach is taken by using this specific terminology. As noted above, the three measures of memory frequency (retro 1, retro 2 and diary) will be analysed separately, in order to carefully distinguish between potentially different ‘types’ of involuntary memories.



The first task is the emotional AX-CPT. Akin to the AX-CPT used previously, the emotional variant requires participants to respond to cue-letter pairs; making a ‘target’ response only to AX trials and ‘non-target’ responses to AY, BX and BY trials. However, in the emotional version the letters are superimposed onto happy or sad faces. Importantly, the faces and the emotional information provided by the faces, are irrelevant to the response requirement. Therefore, the task assesses the ability to maintain context in the presence of irrelevant emotional information. The emotional AX-CPT has previously been used to demonstrate that performance of patients with schizophrenia was more impaired when the letters pairs were on happy faces compared to sad or neutral faces (Park, Kim, Kim, Kim, & Lee, 2011). Control participants’ performance was not affected by the background faces. The authors thus concluded that the processing of the happy faces in individuals with schizophrenia took resources away from the actual requirements of AX-CPT, thereby impacting their performance. It remains to be determined whether low mood and other variables related to intrusive memory experience, for example memory-related distress and rumination, have a similar impact on task performance.

In addition to incorporating emotional stimuli, there will be another modification to the AX-CPT, namely a change in the SOAs used. This is to address the previous two studies’ lack of BX/BY difference, i.e. lack of reactive control measure. As previously discussed, the long SOA condition used for chapter four and five was too short. Performance suggests that participants were sufficiently able to maintain cue-based information over both SOAs, and did not need to engage in any target-based processing. Consequently, in the current study the target letter will be presented either 1000 ms or 10 000 ms after the cue letter, compared to the 700 ms and 4700 ms SOAs

used previously. This brings the study into line with Msetfi et al. (2009) who, in contrast to the previous two chapters, found that high BDI-II participants were selectively impaired in the ability to maintain context over time. This adjustment to the long SOA is important because if the interval between the cue and target becomes too long, proactive control will become too costly to maintain and increased reliance on reactive (i.e. target-letter) control (Braver et al., 2007) would become the optimal form of processing on the task. Increasing the sensitivity of the task in this way may reveal intrusive memory group differences in cognitive control that did not previously emerge.

The second measure of cognitive control in this study will be the emotional Stroop task. The Stroop task is a common measure of cognitive control, and changes on Stroop task performance as a function of aging (Cohn, Dustman, & Bradford, 1984) and depression (Holmes & Pizzagalli, 2008; Moritz et al., 2002) have previously been demonstrated. In the classic Stroop task (Stroop, 1935), participants are presented with a word written in either a compatible or incompatible ink colour (i.e. the word 'red' written in red or blue ink) and must make a response based on the colour of the ink. Reaction times and error rates are consistently higher during incompatible trials, for example when participants must respond to the word red written in blue ink, than for compatible trials, when the ink colour matches the word presented (MacLeod, 1991). The classic Stroop task has been modified in two different ways to incorporate the processing of affective conflict. In the emotional-word version (Mitterschiffthaler et al., 2008), participants are presented with a depressive-related word (e.g. tired, sad) and again respond to the ink colour of the word. In the emotional-face version (Etkin et al., 2006), participants are presented with the word happy or sad presented below a happy or sad face, and are instructed to respond to the valence of the face. In both

cases the words are task-irrelevant. The emotional-face Stroop task will be used in the current study to determine if these irrelevant faces impact performance.

There are two aspects of Stroop task performance which can be looked at in terms of potential individual differences in proactive and reactive control. As per Saunders and Jentsch (2014), speed accuracy trade-off (SAT) instructions can be manipulated to determine whether individuals can effectively use an instruction to modify their behaviour. This would entail responding faster when instructed to prioritise speed, and making fewer errors when instructed to prioritise accuracy. The ability to use the instruction to modify behaviour reflects sustained biasing of behaviour prior to stimulus presentation; i.e. proactive control (Braver, 2012) and can be indexed by comparing performance (both reaction times and error rates) on blocks where participants are instructed to respond quickly, to blocks where participants are instructed to respond accurately (Saunders & Jentsch, 2014). Reactive control can be indexed through examining the effect of previous trial compatibility on current trial performance. This is termed the conflict sequence effect (CSE) and typically reflects reduced interference following an incompatible trial, as compared to a compatible trial (Botvinick et al., 2001). The CSE is assumed to reflect increased top-down attentional control after the detection of conflict (Gratton, Coles, & Donchin, 1992), in order to reduce the impact of irrelevant stimulus dimensions on future trials (Botvinick et al., 2001; Botvinick, Cohen, & Carter, 2004). This modification therefore represents reactive control, i.e. a ‘late correction’, mechanism (Braver, 2012). It should be noted that one other interpretation is that the CSE indicates a short-term increase in *proactive* control, that is activated in a reactive manner. However, it is argued that the short-term scale of the increase in attentional control,

and the speed at which the increase is implemented (Jiménez & Méndez, 2014, Scherbaum, Dshemuchadse, Fischer & Goschke, 2010), as compared to the long-term, sustained, effects of proactive control (Braver, 2012, Dipisapia & Braver, 2006), does underline the utility of a Dual Mechanisms account. For example, in the current Stroop task, proactive control is reflected by the long-term biasing of attention on a block-by-block basis, whereas the CSE reflects changes on more trial-by-trial basis. Therefore, for the purpose of the present study, the CSE will be taken as a measure of reactive control, although this potential limitation is important to bear in mind going forward. As noted above, these indices of proactive and reactive control, SATs and CSEs, have not been looked at in relation to intrusive memory experience.

Some work has looked at CSEs in relation to depression symptomatology. A study by Holmes and Pizzagalli (2007) suggested that depressive-related deficits emerge particularly in relation to negative events, for example following the execution of an error, or in relation to perceived failure. While the low BDI-II group ( $\leq 5$ ) showed a typical conflict adaptation effect, participants with high BDI-II scores ( $\geq 13$ ) did not show a reduction in the Stroop effect after a previous incompatible trial compared to a previous compatible trial. In contrast, the low BDI-II group did. This suggests that high BDI-II participants had a reduced ability to moderate their behaviour from one trial to the next, reflecting a deficit in reactive control. Consistent with that finding, Saunders and Jentsch (2014) demonstrated that high BDI-II participants (BDI-II scores  $\geq 17$ ) showed reduced CSEs on the emotional-face Stroop, compared to low and medium BDI-II participants (BDI-II  $< 17$ ). Conversely, contrary to their predictions, proactive control (speed accuracy trade-offs) did not vary as a function of depressive symptomatology. Therefore, the current study aims to determine whether the selective deficit in reactive control is replicable in the current study, as the DMC

predicts a depressive-related deficit in proactive control. Importantly, in the Saunders and Jentsch (2014) paper, no differences in either proactive or reactive control emerged on the classic Stroop task, supporting the importance of emotional tasks to uncover depressive related deficits. This is further motivation to examine whether emotional tasks are important to discover intrusive memory related deficits.

As discussed in previous chapters, the studies that have looked at the link between intrusive memory and cognitive control have mainly focused on proactive interference (Verwoerd et al., 2009; Verwoerd et al., 2011). These studies have demonstrated that individual differences in proactive interference susceptibility are associated with intrusive memory experience; a higher ability to resist proactive interference was related to fewer intrusive memories of a film-fragment (Verwoerd et al., 2011) and fewer intrusive memories of a past stressful event (Verwoerd et al., 2009). When Verwoerd et al. (2009) looked at proactive interference, they also looked at performance on the classic Stroop task as a measure of response inhibition. On the Stroop task, they looked at the proportional increase in RTs between incongruent (e.g. the word RED written in blue) and neutral trials (e.g. asterisks (\*\*\*) written in blue). This comparison reflects a pure measure of the cost of incompatibility on the task, rather than including trials when performance is facilitated by congruency, for example the finding that responses are typically faster to the word RED written in red ink than responses to asterisks presented in RED (Lindsay & Jacoby, 1994). Using hierarchical multiple regression, Verwoerd et al. (2009) found that there was no relationship between Stroop performance and the IES scores for participants' past stressful event. The authors therefore concluded that response inhibition does not play a role in intrusion vulnerability. However, as reasoned above, the emotional content

of intrusive memories may mean that intrusive-memory related deficits require affective cognitive tasks to emerge. As such, using the emotional Stroop is an important extension of this previous study. The present study will also use a more precise measure of memory frequency than the Verwoerd et al. (2009) study, which used the IES as the measure of intrusive memory experience. The IES does not specifically index intrusive frequency, but instead asks participants to rate subjective aspects of frequency in relation to vague statements (e.g. pictures about it popped into my mind; never, often, sometimes, always). While an abundance of research supports the importance of such subjective evaluations of memories for determining distress (Newby & Moulds, 2011c; Williams & Moulds, 2008b), research into potential cognitive deficits should begin with a clear assessment of memory frequency, along with subjective measures. Therefore, as for the study on intrusive memory presented in chapter four, both frequency specific measures (retrospective and diary ratings) and measures looking at the consequences of the memory (the IES and the trait rumination scale) will be used to index the overall experience of these memories.

In summary, the present research has two aims. The first aim is to determine if more robust measures of proactive and reactive control than those provided by the AX-CPT are necessary for an underlying link between cognitive control deficits and intrusive memory experience to emerge. This will be addressed using the Stroop task. The second aim is to incorporate emotional stimuli into both the AX-CPT and Stroop tasks, in order to determine if the null findings of the previous two empirical chapters reflect the unvalenced material used. Once again, the correlations between the questionnaires will also be looked at, in order to replicate relationships found in the

previous chapters and to form a clear picture of the characteristics of the sample being tested.

### **Predictions:**

#### **1) Emotional AX-CPT:**

As predicted for the previous AX-CPT studies, significant main effects of SOA (short, long) and condition (AY, BX, BY) are predicted. The effect of SOA is predicted to be dependent on context maintenance abilities; if participants can adequately maintain context over the duration, BX performance should stay constant or improve in long SOA trials, whereas performance on AY trials is predicted to stay constant or get worse with the increased delay. Conversely, if context maintenance is impaired, then BX performance should worsen with delay, while AY performance should improve. Performance is also expected to differ significantly between AY, BX and BY trials. Specifically, RTs are expected to be longer and error rates higher to AY trials than to BX and BY trials. With the extension of the long SOA, there is also predicted to be a difference in performance BX and BY trials, with longer RTs/more errors made in to BX trials as compared to BY trials.

#### **2) Emotional Stroop:**

Significant main effects of SAT instruction (speed, accuracy) and compatibility (compatible, incompatible) are predicted. Specifically, RTs are predicted to be faster and error rates higher under speed instructions than under accuracy instructions. RTs and error rates are also predicted to be higher for incompatible than compatible trials; the classic Stroop effect. Additionally, RTs and error rates are expected to be affected by the compatibility of the previous trial, in that the Stroop effect will be reduced following an incompatible trial than following a compatible trial (indexed through a

current compatibility x previous compatibility interaction), suggesting the presence of conflict adaptation effects.

### **3) Group comparisons:**

It is subsequently predicted that cognitive control, as measured by the emotional AX-CPT and Stroop tasks, will be affected by between-group differences in intrusive-memory experience (both frequency and consequences of the memory measures) and depressive symptomatology. On the AX-CPT, predictions which were not previously met are expected to emerge given the changes to the SOA, and the incorporation of emotional stimuli. Specifically, participants experiencing a high number of intrusive and negative memories, and scoring more highly on the other self-report measures (intrusive-memory distress, trait rumination and depressive symptomatology) are expected to show less proactive control (cue-letter processing). As a consequence of this reduced proactive control on the task, they are therefore expected to need to rely more on reactive control (target-letter processing). This would emerge as better AY performance, but impaired BX performance. As these variables are predicted to impair the maintenance of contextual information, these findings are predicted to be more pronounced in the long SOA trials. On the Stroop task, participants experiencing more memories and scoring more highly on the questionnaires are predicted to be more impacted by the irrelevant emotional information. This may be reflected through a reduced ability to use the speed/accuracy instruction to make block-by-block modifications to behaviour (i.e. proactive control), or showing reduced behaviour modification after the experience of conflict. Previously, predictions in the thesis were that participants scoring highly on the questionnaires would show a specific deficit in proactive control. Conversely, Saunders and Jentsch (2014) previously demonstrated that, on the emotional Stroop, participants high in depressive symptomatology, as



measured by the BDI-II, showed a deficit in their ability to modify behaviour following conflict, i.e. a deficit in reactive control, and no deficit in proactive control. The lack of proactive control deficit was contrary to their predictions. Therefore, it remains to be determined whether any intrusive-memory related deficits on the emotional Stroop will be in proactive or reactive control.

## **Method:**

### *Participants:*

The study received ethical approval from the University Teaching and Research and Ethics Committee (UTREC). Participants volunteered for the study through the SONA system and through adverts on the University memo bulletins. To take part, participants had to have recently experienced an intrusive memory and speak English fluently. In total 44 participants took part in the study. One participant was excluded as they reported a number of intrusive memories more than 3 SDs above the mean (reporting 70 intrusive memories during the Intrusive Memory Interview, details below). Consequently, 43 participants remained for the analysis (31 female, 12 male, age range 17-28). No other data points were more than 3 SDs above the mean and therefore no other data were excluded. Due to a technical error, only data for 42 participants is available for the AX-CPT task. Power analysis revealed that sample size of 34 would be required to detect a medium effect size at a 95% confidence interval using an alpha of .05. Participants were reimbursed £10 for their time.

### *Emotional AX-CPT:*

Stimuli were single letters, presented on the nose of a face (100 mm x 70 mm) taken from the Ekman and Friesen (1976) set of happy and sad faces. For both tasks, faces were masked to remove hair, body and any background information. The faces were presented in grey scale and the letters were in white font. See Figure 6.1. The cue

letter consisted of either an A or a B letter, and target letters consisted either an X or a Y. The target-letter required a left-handed ‘target’ response (keyboard letter z) only if preceded by the letter A. Any other cue-target pair required participants to make a right-handed ‘non-target’ response (keyboard letter m). Each trial began with a fixation cross on screen (300 ms), followed by the cue-letter (300 ms), followed by a SOA (either 1000 ms or 10 000 ms), followed by the target-letter (presented until response) and finally the screen was blank (300 ms). See Figure 6.1 for an example of a single trial sequence below.

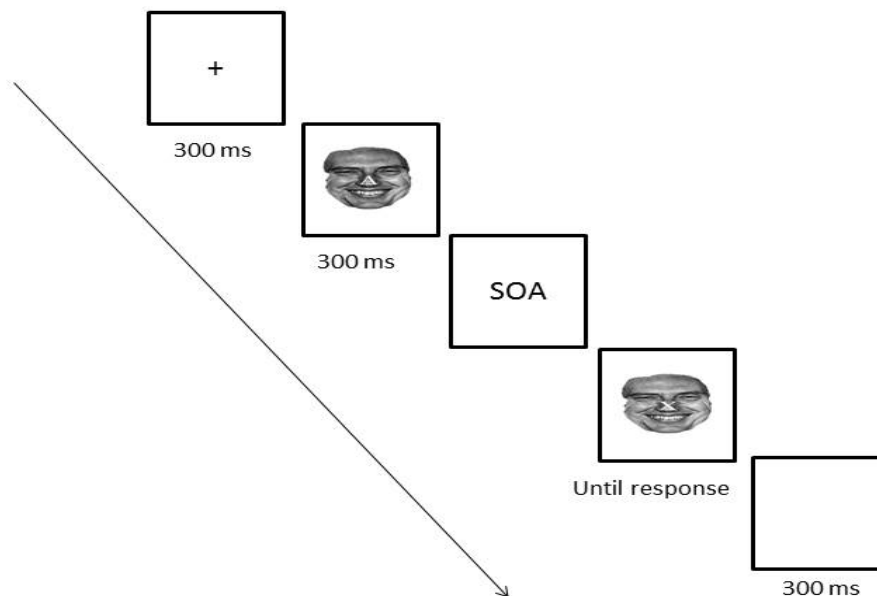


Figure 6.1. An example of single trial sequence in the Emotional AX-CPT task

The task consisted of 2 blocks, each containing 108 trials. At the end of each block participants could take a short break. 70% of the trials were AX trials, and the rest were divided equally between AY, BX and BY trials (10% each). Within those frequencies, half of the cue-target combinations were presented on a happy face, half

were presented on a sad face. The cue-target letter pairs were always presented on the same face, displaying the same valence. After being taken through the instructions, participants began with a practice block consisting of 10 cue-target letter pairs and were given feedback after each practice trial. They were subsequently given the opportunity to ask the researcher any questions before beginning the experimental trials.

*Emotional Stroop task:*

The stimuli were presented centrally on screen. The stimuli set consisted of 16 faces; 4 male, 4 female, each with a happy and a sad version (Ekman & Friesen, 1976). The faces measured approximately 60 mm x 35 mm. The word 'HAPPY' or 'SAD' (printed in capital letters) was presented below each face, see Figure 6.2 for an example. Each letter measured approximately 10 mm x 7 mm. Participants completed two blocks, each made up of 200 stimuli and could take a short break between each block. Stimuli were presented until response, and between each trial, a fixation point appeared for 1500 ms. At the beginning of each block, participants were instructed to respond as quickly or as accurately as possible and these instructions were reversed for the subsequent block. Participants were instructed to make either a left-handed (keyboard letter z) or right-handed response (keyboard letter m) depending on whether the face was happy or sad. This was balanced across participants. After being provided with the instructions participants completed 8 practice trials and continued onto the experimental trials.

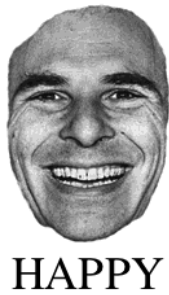


Figure 6.2. An example of a compatible condition in the Emotional-Face Stroop task.

*Procedure:*

After providing informed consent, participants completed the two computer tasks in a randomized order. Participants were then taken through the Intrusive Memory Interview and completed the IES, RRS and BDI-II, in a randomized order. Next participants were given the instructions for keeping the diary over the next 7 days, after which they returned to the research laboratory to hand in their diaries and to be debriefed and reimbursed for their time.

**Results:**

**1) Overall task data:**

**Emotional AX-CPT:**

Overall task data will be analysed using a repeated-measures ANOVA with the within-subjects factors valence (happy, sad) and SOA (short, long) for the 'target' (AX) trials. For the 'non-target' trials, a repeated-measures ANOVA with the within-subjects factors valence (happy, sad), SOA (short, long) and condition (AY, BX, BY) will be conducted. After the overall data is presented, the groups will be compared on task performance. The following group splits were conducted: retro 1, retro 2, diary, IES, RRS, BDI-II and extreme BDI-II. For the 'target' trials this will consist of a repeated-measures ANOVA with the within-subjects factors valence (happy, sad) and

SOA (short, long) and the between-subjects factor (as defined in the following sections). For the ‘non-target’ trials, this will comprise of a repeated-measures ANOVA with the within-subjects factors valence (happy, sad), SOA (short, long) and condition (AY, BX, BY) and the between-subjects factor (as defined in the following sections). For the between-group analyses, only effects involving the factor group will be reported. Bonferroni corrections were made to post-hoc comparisons.

RTs and error rates for all trial types are displayed in Figure 6.3 below, split by short (1000 ms) and long (10 000 ms) SOA intervals.

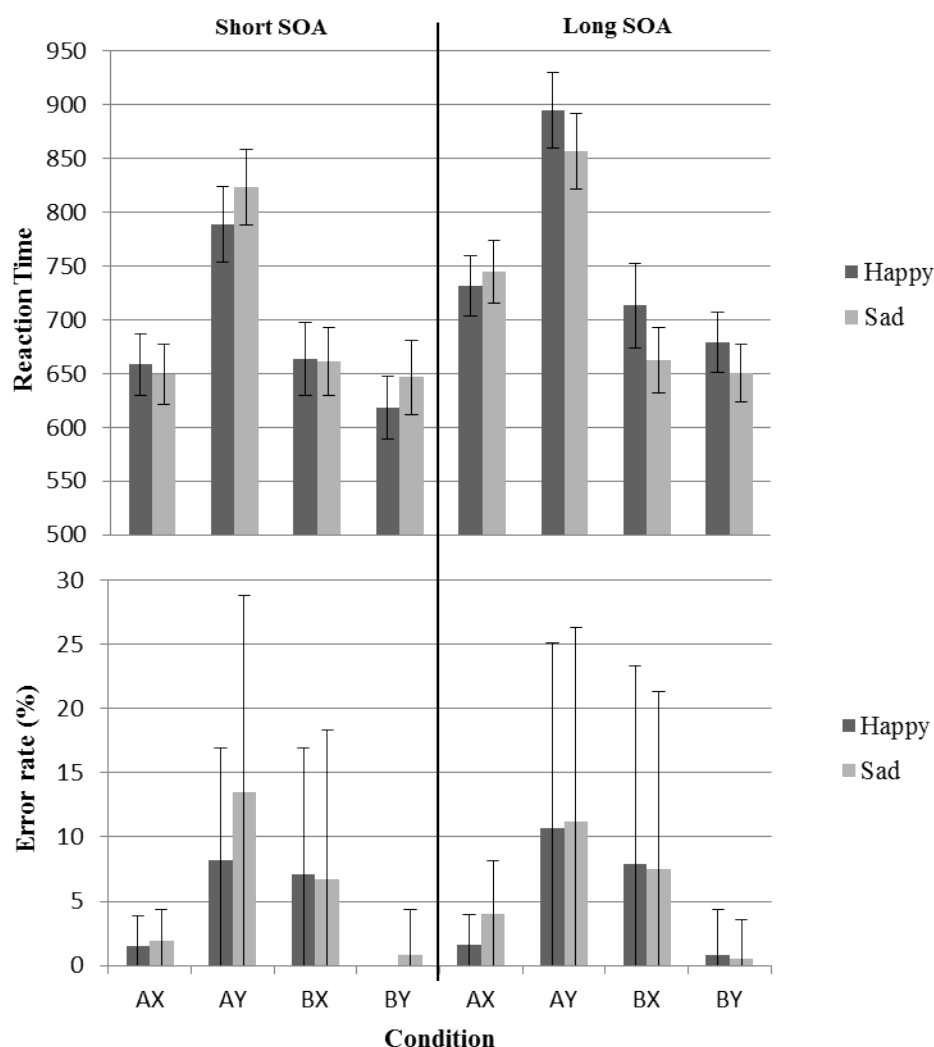


Figure 6.3. Mean RTs and error rates (with standard error bars) for each trial type over the two SOAs.

**i) Target (AX) trials:**

**RTs:** The main effect of SOA was significant,  $F(1, 41) = 42.77$ ,  $p = .01$ , partial  $\eta^2 = .51$ . RTs were significantly faster for the short SOA condition (mean = 654 ms, SD = 27.88) than for the long SOA condition (mean = 738 ms, SD = 28.45). The valence x SOA was significant,  $F(1, 41) = 5.38$ ,  $p = .03$ , partial  $\eta^2 = .17$ . Responses were faster for sad than happy stimuli at the long SOA (mean happy = 732 ms, SD = 28.4, mean sad = 744 ms, SD = 29.3), but this effect was slightly reversed for the short SOA (mean happy = 659 ms, SD = 28.3, mean sad = 650 ms, SD = 28). Neither comparison, however, was significant, both  $F$ s  $< 1.77$ , both  $p$ s  $> .05$ . No other effects reached significance,  $p$ s  $> .10$ .

**Error rates:** Kolmogorov-Smirnov tests revealed that the error data were not normally distributed,  $D_s(42) > 1.7$ ,  $p$ s  $< .01$ . The data were therefore arcsine transformed and submitted to a repeated-measures ANOVA. However, the means reported in the text and shown in the figures are based on the original data. The main effect of valence was marginally significant,  $F(1, 41) = 8.70$ ,  $p = .05$ , partial  $\eta^2 = .18$ . More errors were made to sad stimuli (mean = 2.96%, SD = .42) than to happy stimuli (mean = 1.61%, SD = .26). The main effect of SOA was also significant,  $F(1, 41) = 5.45$ ,  $p = .03$ , partial  $\eta^2 = .12$ . More errors were made in the long SOA (mean = 2.85%, SD = .39) than the short SOA (mean = 1.72%, SD = .29). The valence x SOA interaction was significant,  $F(1, 41) = 5.50$ ,  $p = .02$ , partial  $\eta^2 = .12$ . For the long SOA, participants made significantly more errors to sad stimuli (mean = 4.05%, SD = .63) as compared to happy stimuli (mean = 1.65%, SD = .37),  $F(1, 41) = 13.60$ ,  $p = .01$ , partial  $\eta^2 = .25$ . However at the short SOA, there was no difference between

happy (mean = 1.56%, SD = .35) and sad stimuli (mean = 1.87%, SD = .38),  $F(1, 41) = 0.34$ ,  $p > .05$ .

**ii) Non-target (AY, BX, BY) trials:**

**RTs:** The main effect of SOA was significant,  $F(1, 41) = 12.09$ ,  $p = .01$ , partial  $\eta^2 = .23$ . RTs were significantly faster to the short SOA (mean = 700 ms, SD = 28.51) condition than for the long SOA condition (mean = 743 ms, SD = 27). The main effect of condition was also significant,  $F(2, 82) = 63.28$ ,  $p = .01$ , partial  $\eta^2 = .61$ . Responses to AY trials were significantly slower (mean = 841 ms, SD = 31.20) than both BX (mean = 675 ms, SD = 29.56) and BY trials (mean = 649 ms, SD = 26.41), both  $F_s > 48.70$ ,  $p_s < .01$ , partial  $\eta^2_s > .55$ . The difference between BX and BY trials was not significant,  $F(1, 41) = 3.39$ ,  $p > .05$ . The valence x SOA interaction was significant,  $F(1, 41) = 6.63$ ,  $p = .01$ , partial  $\eta^2 = .14$ . That is, the main effect of SOA was only present for the happy stimuli,  $F(1, 41) = 17.59$ ,  $p = .01$ , partial  $\eta^2 = .30$  (mean short: 690 ms, SD = 28.02, mean long: 762 ms, SD = 30.0) but not for the sad stimuli,  $F(1, 41) = .62$ ,  $p > .05$  (mean short: 711 ms, SD = 31.1, mean long: 724ms, SD = 26.1). No other effects were significant, all  $F_s < 1.8$ , all  $p_s > .05$ .

**Error rates:** The main effect of condition was significant,  $F(1, 40) = 25.86$ ,  $p = .01$ , partial  $\eta^2 = .39$ . Pairwise comparisons (Bonferroni corrected) revealed that the difference in errors made to AY (mean = 10.74%, SD = 1.64) and BX trials (mean = 7.32%, SD = 1.37) was not significant,  $F(1, 41) = 3.55$ ,  $p > .05$ , partial  $\eta^2 = .08$ . The difference in errors made to AY and BY (mean = 0.52%, SD = .22) trials was significant,  $F(1, 41) = 56.48$ ,  $p = .01$ , partial  $\eta^2 = .58$ . Importantly, the difference in errors made to BX and BY trials was significant,  $F(1, 41) = 32.91$ ,  $p = .01$ , partial  $\eta^2 = .45$ . No other effects were significant,  $F_s < 2.40$ ,  $p_s > .09$ .

*Task summary:* Some of the effects of the previous AX-CPTs used in chapters four and five were replicated. RTs were slower to AY trials than to both BX and BY trials. Furthermore, even with the increased SOA, there was still no significant difference in RTs to BX and BY trials. As the previous two chapters, however, this difference did emerge in the error rate data, where participants made more errors to BX trials as compared to BY trials. This BX/BY difference is important as it demonstrates that participants did not always fully use the cue-letter information in the task, as the X in BX trials was misleading. The addition of valence to the task did not greatly impact participants' RT performance. The only effects were some valence x SOA interactions, which are a bit muddled. Participants were more conservative in their responses to happy stimuli on 'target' trials with a long SOA, as compared to those with a short SOA. However on 'non-target' trials, participants were significantly faster to happy stimuli short SOA trials as compared to happy stimuli long SOA. There has not been a lot of research using the emotional AX-CPT, so the general lack of impact of valence is difficult to interpret. Extending the SOAs reversed the effect of SOA found in the previous two chapters; participants in this study were slower (on both 'target' and 'non-target' trials) and made more errors (on 'target' trials only) in the long SOA trial, as compared to short SOA trials. This suggests participants did have some difficulty with, or no longer saw the benefits of, maintaining context over time. This finding supports the Dual Mechanisms Theory of cognitive control, which highlights the importance of flexibility (Braver et al., 2007).



**Emotional Stroop task:**

The Stroop data were analysed using a 2 (SAT instruction: speed, accuracy) x 2 (previous compatibility: compatible, incompatible) x 2 (current compatibility: compatible, incompatible) repeated-measures ANOVA.

**RTs:** There was a significant main effect of instruction,  $F(1, 42) = 44.19$ ,  $p = .01$ , partial  $\eta^2 = .51$ . RTs were significantly faster under speed instructions (mean = 569 ms, SD = 13.65) than under accuracy instructions (mean = 694 ms, SD = 22.4). The main effect of previous compatibility was not significant,  $F(1, 42) = .02$ ,  $p > .05$ . The main effect of current compatibility was significant,  $F(1, 42) = 23.9$ ,  $p = .01$ , partial  $\eta^2 = .36$ . RTs were faster to compatible trials (mean = 621 ms, SD = 15.53) than for incompatible trials (mean = 642 ms, SD = 16.69). No interactions were significant, all  $F_s < .93$ , all  $p_s > .05$ .

**Error rates:** The main effect of instruction was significant,  $F(1, 42) = 28.76$ ,  $p = .01$ , partial  $\eta^2 = .41$ . The percentage of errors made was higher under speed instructions (mean = 10.16%, SD = 1.15) than under accuracy instructions (mean = 5.58%, SD = .97). The main effect of previous compatibility was not significant,  $F(1, 42) = 2.51$ ,  $p > .05$ . The main effect of compatibility was significant,  $F(1, 42) = 25.62$ ,  $p = .01$ , partial  $\eta^2 = .38$ . The percentage of errors made was higher for incompatible trials (mean = 9.38%, SD = 1.11) than for compatible trials (mean = 6.37%, SD = .91). No interactions were significant, all  $F_s < 2.17$ , all  $p_s > .15$ .

*Task summary:* Overall, participants responded faster when told to prioritize speed, and made fewer errors when told to prioritize accuracy. This reflects appropriate speed-accuracy trade-offs, i.e. proactive control. RTs and error rates were also higher for incompatible trials as compared to compatible trials, indicating the presence of a Stroop effect. Surprisingly, however, no significant interaction between previous compatibility and compatibility was found, suggesting the absence of the CSE effect. Therefore, group analyses were subsequently conducted without this factor. Group comparisons were therefore conducted with a 2 (SAT instruction: speed, accuracy) x 2 (compatibility: compatible, incompatible) repeated-measures ANOVA with group as a between-subjects factor.

## **2) Group comparisons:**

Table 6.1 below displays the descriptive statistics for each of the questionnaires. It also explains the composition of the high and low groups; consistent with the previously presented studies, these were based on mean splits. As noted above, there was a technical problem recording AX-CPT performance for one participant, therefore the AX-CPT groups contain one fewer participant than the Stroop groups.

Table 6.1

*Means, standard deviations (SD) for each of the questionnaire measures and the composition of the groups based on mean splits.*

Variable	Mean	S.D.	Group split value	N High (AX-CPT)	N Low (AX-CPT)	N High (Stroop)	N Low (Stroop)
<b>Retro 1</b>	5.10	8.42	High $\geq 5$	18	24	19	24
<b>Retro 2</b>	7.16	7.85	High $\geq 7$	15	27	16	27
<b>Diary</b>	4.53	4.01	High $\geq 5$	18	24	19	24
<b>IES</b>	33.67	16.75	High $\geq 34$	21	21	22	21
<b>RRS</b>	45.77	11.15	High $\geq 46$	21	21	22	21
<b>BDI-II</b>	11.30	7.98	High $\geq 11$	21	21	22	21
<b>Extreme BDI-II</b>	11.53	9.44	High $\geq 17$ , low $< 7$	13	17	13	17

Once again, the intrusive memories consisted of similar events to previous research (Brewin et al., 1996, Newby & Moulds, 2012). These were relationship/family issues (e.g. a relationship break up, argument with Father), work/school issues or personal failure (e.g. provisional PhD supervisor telling me she couldn't be my supervisor, performing badly in a dance show) and death/illness of another (e.g. watching the ducks as my Grandfather died, being with my Dad when he almost died). The mean rating of intrusive memory distress was 64.04 out of 100 (SD = 20.64).

### **Emotional AX-CPT:**

#### **i) 'Target (AX) trials':**

F-values for 'target' trials for each between-group comparison are presented below in Tables 6.2 and 6.3, for reaction times and error rates respectively. Only one comparison was significant and one comparison approached significance. Figures for the significant values are presented below the tables.

Table 6.2

*F-values for reaction times to 'target' trials for each between-group variable. Significant F-values are presented in bold.*

	Retro 1	Retro 2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	2.08	1.34	0.69	0.29	0.15	0.38	0.12
<b>Group x valence</b>	0.53	0.11	0.55	0.26	0.42	0.44	0.10
<b>Group x SOA</b>	1.20	1.80	2.45	0.01	1.51	0.02	0.90
<b>Group x valence x SOA</b>	0.23	0.48	1.80	0.02	2.91	3.40	<b>4.61 *</b>

**\*\***  $p < .01$ , **\***  $p < .05$ , **(\*)**  $p < .10$

Table 6.3

*F-values for error rates to 'target' trials for each between-group variable. Significant F-values are presented in bold.*

	Retro 1	Retro 2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.20	0.60	0.05	0.88	0.16	0.03	0.01
<b>Group x valence</b>	0.38	0.77	3.78 (*)	0.84	0.49	0.11	0.06
<b>Group x SOA</b>	0.85	0.10	0.10	1.65	0.07	0.32	0.48
<b>Group x valence x SOA</b>	1.02	0.46	1.43	0.22	1.67	0.27	1.46

**\*\***  $p < .01$ , **\***  $p < .05$ , **(\*)**  $p < .10$

**RTs:** The extreme BDI-II group x valence x SOA group interaction was significant,  $F(1, 28) = 4.61$ ,  $p = .04$ , partial  $\eta^2 = .14$ . Post-hoc comparisons (Bonferroni corrected) revealed that the valence x SOA interaction was only present in the low extreme BDI-II group,  $F(1, 16) = 6.42$ ,  $p = .02$ , partial  $\eta^2 = .29$ , but not in the high extreme BDI-II group,  $F(1, 12) = 0.45$ ,  $p > .05$ . Further breakdowns of the low extreme BDI-II group performance showed a significant difference between the SOAs for both the happy ( $t(17) = -3.32$ ,  $p = .01$ ) and sad ( $t(17) = -4.27$ ,  $p = .01$ ) stimuli. However, the difference was larger in the sad stimuli (difference = 106 ms) than in the happy stimuli (difference = 71 ms). These effects are displayed in Figure 6.4 below.

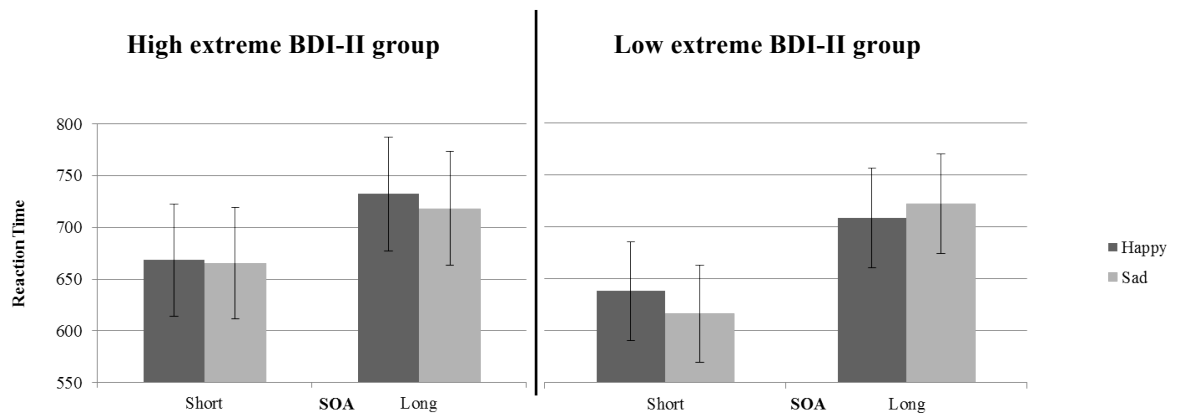


Figure 6.4. Mean RTs (with standard error bars) for ‘target’ trials, for the high and low extreme BDI-II groups respectively.

**Error rates:** The diary group x valence interaction approached significance,  $F(1, 40) = 3.78$ ,  $p = .06$ , partial  $\eta^2 = .09$ . Pairwise comparisons (Bonferroni corrected) revealed this reflected a significant effect of valence in the high diary group,  $F(1, 17) = 14.42$ ,  $p = .01$ , partial  $\eta^2 = .46$ , where more errors were made to sad stimuli than happy stimuli (mean sad = 3.68%, SD = .63, mean happy = 1.40%, SD = .40). There was no effect of valence in the low diary group,  $F(1, 23) = 0.95$ ,  $p > .05$ , partial  $\eta^2 = .04$  (mean happy = 1.76%, SD = .35, mean sad = 2.42%, SD = .54). This is displayed in Figure 6.5 below.

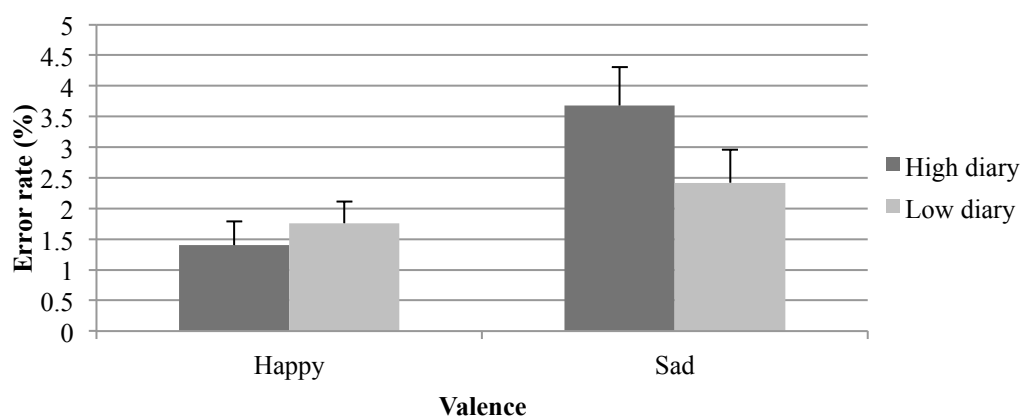


Figure 6.5. Mean error rates (with standard error bars) for happy and sad stimuli, split by high and low diary groups.

## ii) Non-target ‘(AY, BX, BY)’ trials:

There were five between-group comparisons on ‘non-target’ trials that were significant, and two that approached significance. F-values for all comparisons are presented in the Tables 6.4 and 6.5 below, for reaction time and error rates respectively. Figures for the significant values are presented below the tables.

Table 6.4

*F-values for **reaction times** to ‘non-target’ trials. Significant F-values are presented in bold.*

	Retro 1	Retro 2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	1.10	1.48	0.36	0.01	0.01	0.38	0.17
<b>Group x condition</b>	1.99	0.16	1.22	<b>3.83*</b>	0.84	0.83	0.04
<b>Group x valence</b>	2.95	0.34	0.01	0.72	0.27	0.38	0.26
<b>Group x SOA</b>	0.02	0.06	1.36	0.52	2.07	0.01	1.65
<b>Group x condition x valence</b>	1.56	0.43	0.58	0.06	0.60	0.02	0.02
<b>Group x condition x SOA</b>	0.75	1.41	1.85	1.09	0.87	2.79	<b>3.34*</b>
<b>Group x valence x SOA</b>	<b>4.23*</b>	1.87	2.14	0.45	0.41	0.48	0.04
<b>Group x valence x SOA x condition</b>	1.03	0.27	0.10	1.29	0.50	0.16	1.49

**\*\***  $p < .01$ , **\***  $p < .05$ , **(\*)**  $p < .10$

Table 6.5

*F-values for **error rates** to ‘non-target’ trials. Significant F-values are presented in bold.*

	Retro 1	Retro 2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.39	0.27	0.12	0.07	0.10	0.60	0.76
<b>Group x condition</b>	0.14	0.98	0.01	0.12	0.01	1.65	0.93
<b>Group x valence</b>	0.15	0.25	0.01	0.23	1.17	0.12	1.57
<b>Group x SOA</b>	0.36	0.07	0.30	0.19	2.09	0.07	0.22
<b>Group x condition x valence</b>	1.03	0.98	0.26	3.06(*)	0.95	0.24	0.64
<b>Group x condition x SOA</b>	2.97 (*)	<b>3.74 *</b>	0.71	1.08	1.76	1.79	1.04
<b>Group x valence x SOA</b>	1.87	2.42	<b>5.68 *</b>	0.65	0.03	0.01	0.12
<b>Group x valence x SOA x condition</b>	1.18	1.08	<b>10.28 **</b>	0.22	0.07	0.14	0.08

**\*\***  $p < .01$ , **\***  $p < .05$ , **(\*)**  $p < .10$

**RTs:** The retro1 group x valence x SOA interaction was marginally significant,  $F(1, 40) = 4.23$ ,  $p = .05$ , partial  $\eta^2 = .10$ . Post-hoc comparisons (Bonferroni corrected)

showed that the valence x SOA interaction was significant in the low retrospective group,  $F(1, 23) = 11.02$ ,  $p = .01$ , partial  $\eta^2 = .32$ , but not in the high retro 1 group,  $F(1, 17) = .04$ ,  $p > .05$ . Further breakdowns of the low retro 1 group performance showed that the effect of SOA was significant in the happy stimuli,  $F(1, 23) = 15.61$ ,  $p = .01$ , partial  $\eta^2 = .40$  (mean short: 697 ms, SD = 42.5, mean long: 788 ms, SD = 42.7), but not significant in the sad stimuli,  $F(1, 23) = 0.21$ ,  $p > .05$ , partial  $\eta^2 = .01$  (mean short = 754 ms, SD = 47.3, mean long = 745 ms, SD = 36.7). These effects are displayed in Figure 6.6 below.

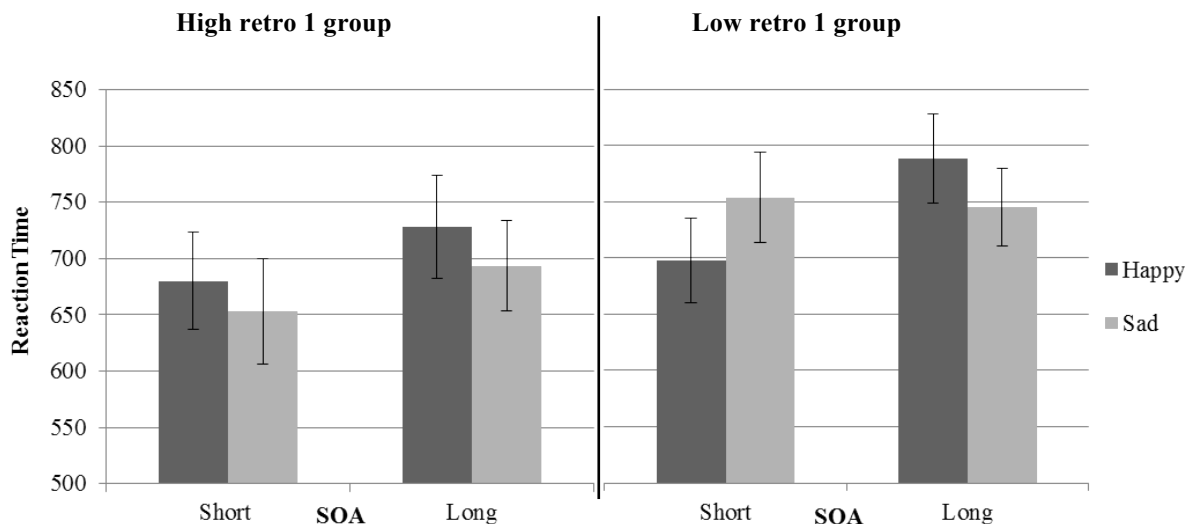


Figure 6.6. Mean RTs (with standard error bars) for ‘non-target’ trials, for high and low retrospective memory groups respectively.

The IES group x condition interaction was significant,  $F(1, 40) = 3.83$ ,  $p = .03$ , partial  $\eta^2 = .09$ . In the high IES group there was a significant difference between AY (mean = 825 ms, SD = 37.4) and both BX (mean = 705 ms, SD = 47.7) and BY trials (mean = 641 ms, SD = 37.6), both  $F_s > 11.27$ , both  $p_s < .01$ . Importantly, there was also a significant difference between BX and BY trials,  $F(1, 20) = 8.79$ ,  $p = .01$ , partial  $\eta^2 = .31$ . In the low IES group, there was a significant difference between AY (mean = 858

ms, SD = 50.6) and both BX (mean = 645 ms, SD = 34.9) and BY (mean = 657 ms, SD = 37.9) trials,  $F_s > 53.9$ ,  $p_s < .01$ , both partial  $\eta^2 > .73$ , but no significant difference between BX and BY trials,  $F(1, 20) = 0.57$ ,  $p > .05$ . These effects are displayed in Figure 6.7 below.

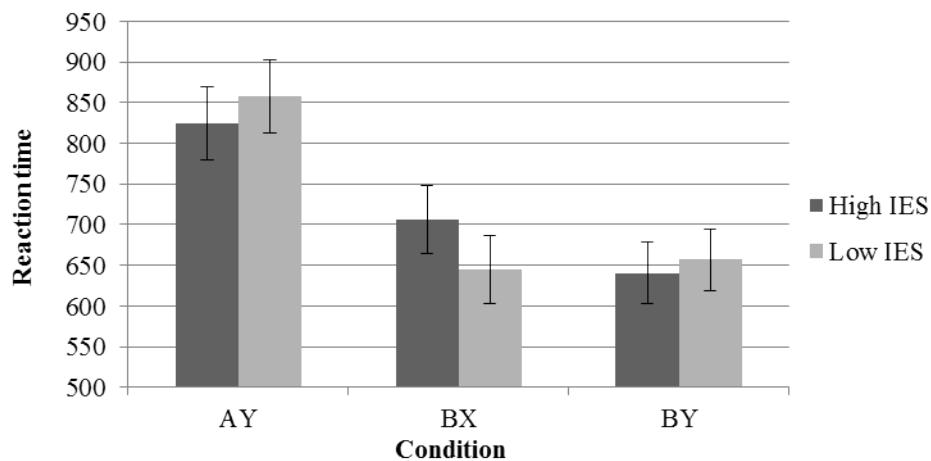


Figure 6.7. Mean RTs (with standard error bars) for ‘non-target’ trials, split by high and low IES groups.

The extreme BDI-II x SOA x condition interaction was significant,  $F(2, 56) = 3.34$ ,  $p = .04$ , partial  $\eta^2 = .11$ . Post-hoc comparisons revealed that the SOA x condition interaction was significant in the high extreme BDI-II group,  $F(2, 24) = 5.39$ ,  $p = .01$ , partial  $\eta^2 = .31$ , but not in the low extreme BDI-II group,  $F(2, 32) = 0.21$ ,  $p > .05$ . Further pairwise comparisons showed that for the high extreme BDI-II group, the difference between the SOAs was significant for AY trials,  $F(1, 12) = 19.97$ ,  $p = .01$ , difference = 89 ms), but that the difference between SOAs was not significantly different for BX,  $F(1, 12) = 0.10$ ,  $p > .05$ , difference = 12 ms, or BY trials,  $F(1, 12) = 0.48$ ,  $p > .05$ , difference = 19 ms. These effects are displayed in Figure 6.8.



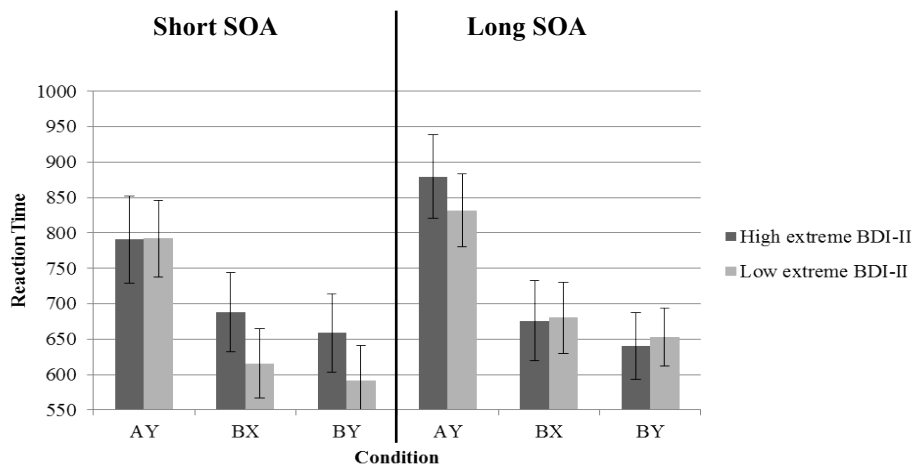


Figure 6.8. Mean RTs (with standard error bars) for ‘non-target’ trials split by high and low extreme BDI-II groups.

**Error rates:** The retro 1 group x condition x SOA interaction was marginally significant,  $F(2, 80) = 2.97$ ,  $p = .05$ , partial  $\eta^2 = .10$ . Further pairwise comparisons revealed that the SOA x condition interaction was not significant in the low retro 1 group,  $F(2, 46) = 0.82$ ,  $p > .05$ . After Bonferroni corrections, the SOA x condition interaction only approached significance in the high retro 1 group,  $F(2, 34) = 3.15$ ,  $p = .05$ , partial  $\eta^2 = .16$ . Therefore this interaction was not broken down any further. These effects are displayed in Figure 6.9.

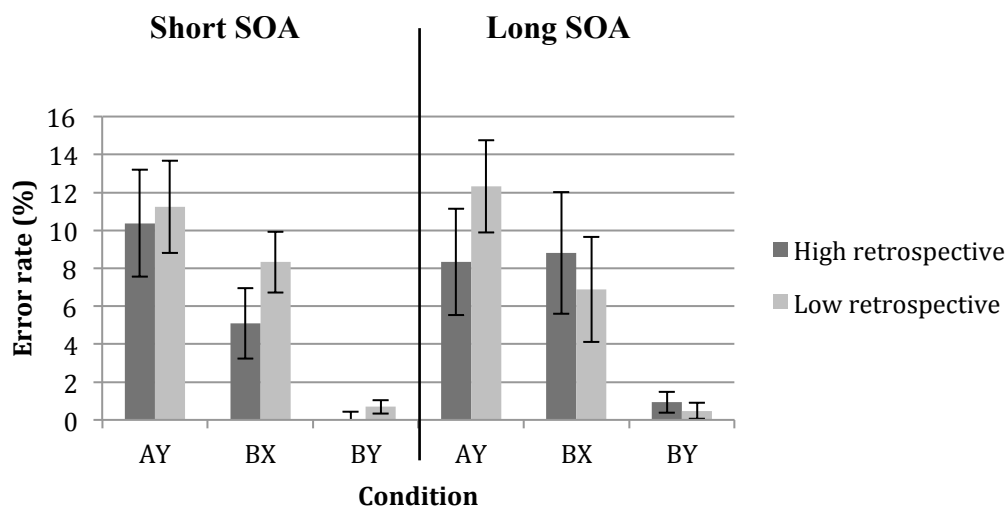


Figure 6.9. Mean error rates (with standard error bars) for the ‘non-target’ trials, split by high versus low retro 1 group.

The retro 2 group x condition x SOA was also significant,  $F(2, 80) = 3.74$ ,  $p = .03$ , partial  $\eta^2 = .09$ . Post-hoc tests showed this reflected a non-significant SOA x condition interaction in the low retrospective 2 group,  $F(2, 52) = 1.40$ , partial  $\eta^2 = .26$  and, after Bonferroni corrections, only a slight trend towards significance in the high retro 2 group,  $F(2, 28) = 2.94$ ,  $p = .07$ . This effect was therefore not further broken-down.

The diary group x valence x SOA interaction was significant,  $F(1, 40) = 5.68$ ,  $p = .02$ , partial  $\eta^2 = .12$ . The valence x SOA interaction was significant in the low diary group,  $F(1, 23) = 13.23$ ,  $p = .01$ , partial  $\eta^2 = .37$  but this interaction was not significant in the high diary group,  $F(1, 17) = 0.51$ ,  $p > .05$ . Further pairwise comparisons (Bonferroni corrected) revealed that in the low diary group the main effect of valence was significant in the short SOA,  $F(1, 23) = 12.89$ ,  $p = .02$ , partial  $\eta^2 = .36$ , but not in the long SOA,  $F(1, 23) = 2.03$ ,  $p > .05$ , partial  $\eta^2 = .08$ . In the short SOA, the low diary group made more significantly errors to sad stimuli (mean = 7.5%, SD = 4.35) as compared to happy stimuli (mean = 4.35%, SD = 0.98). These effects are displayed in Figure 6.10 below.

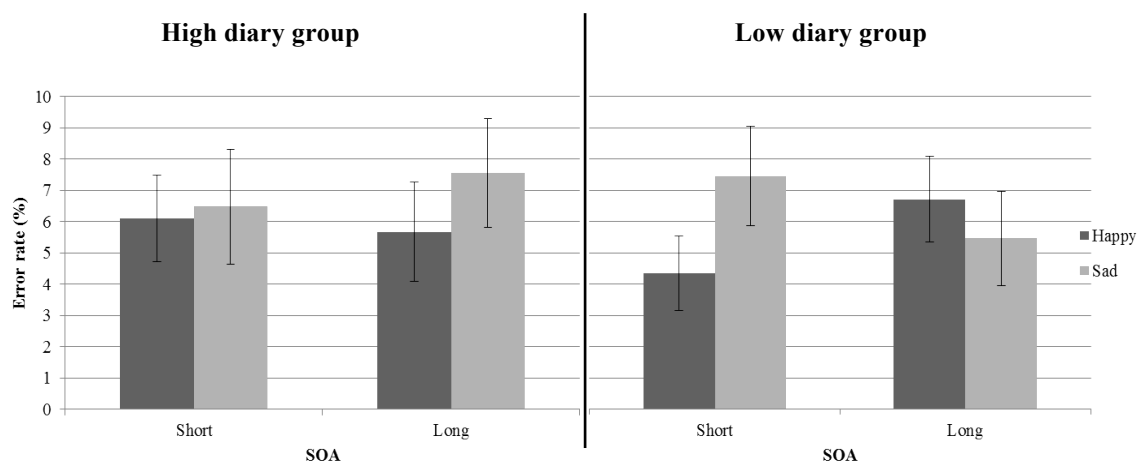


Figure 6.10. Mean RTs (with standard error bars) for 'non-target' trials as a function of SOA (short, long) and valence (happy, sad), for the high and low diary group retrospectively.

The diary group x valence x SOA x condition interaction was also significant,  $F(1, 40) = 10.28$ ,  $p = .01$ , partial  $\eta^2 = .20$ . The valence x SOA x condition interaction was significant in the low diary group,  $F(2, 46) = 9.01$ ,  $p = .01$ , partial  $\eta^2 = .28$  but only approached significance in the high diary group,  $F(2, 34) = 2.84$ ,  $p = .07$ , partial  $\eta^2 = .43$ . Further post-hoc comparisons (Bonferroni corrected) within the low diary group showed that the valence x SOA x condition interaction was significant for AY and BX trials,  $F(1, 23) = 12.45$ ,  $p = .01$ , partial  $\eta^2 = .35$  and for AY and BY trials,  $F(1, 23) = 12.33$ ,  $p = .01$ , partial  $\eta^2 = .35$ . However, this was not significant for BX and BY trials,  $F(1, 23) = 2.84$ ,  $p > .05$ , partial  $\eta^2 = .07$ . Additional pairwise comparisons of the low diary group performance (further Bonferroni corrected) showed these in turn reflected a significant difference between the short and long SOA for sad AY stimuli,  $t(23) = 3.55$ ,  $p = .01$ , where more errors were made to the long SOA trials as compared to short SOA trials. This comparison was also significant for the happy AY stimuli,  $t(23) = -2.44$ ,  $p = .02$ , where more errors were made for short SOA trials (mean = 11.94%, SD = 3.1) as compared to long SOA trials (mean = 5.70, SD = 1.67). None of these comparisons were significant for BX or BY trials, all  $ts < 1.44$ , all  $ps > .16$ . These effects are displayed in Figure 6.11 below.

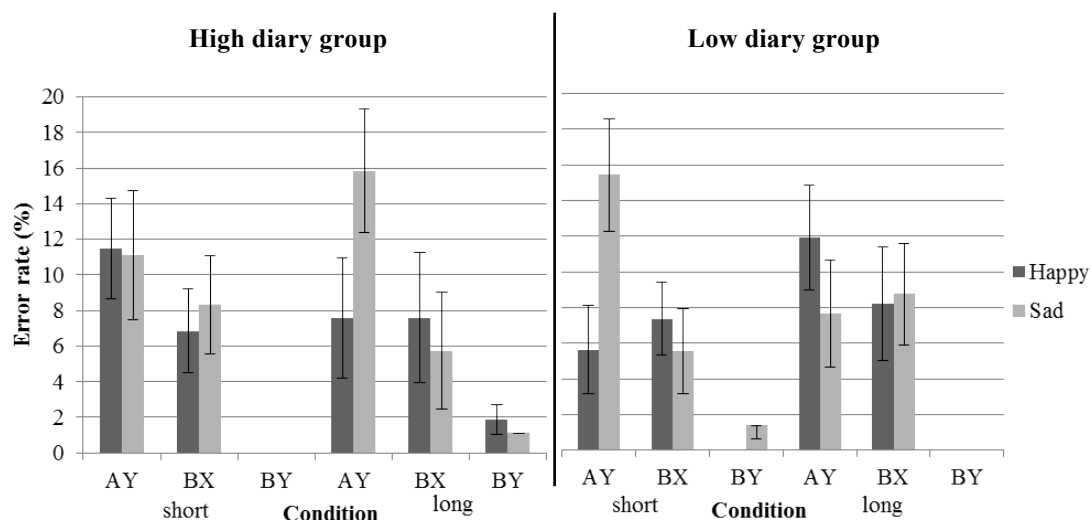


Figure 6.11. Mean error rates (with standard error bars) for 'non-target' trials, over the two SOAs and for the high and low diary group retrospectively.

The IES x condition x valence interaction was marginally significant,  $F(1, 80) = 3.06$ ,  $p = .05$ , partial  $\eta^2 = .20$ . Post-hoc tests (Bonferroni corrected) revealed this reflected a non-significant condition x valence interaction in the low IES group,  $F(2, 40) = 0.37$ ,  $p > .05$  and a significant condition x valence interaction in the high IES group,  $F(2, 40) = 4.70$ ,  $p = .02$ , partial  $\eta^2 = .19$ . Further analysis confirmed that, in the high IES group, the main effect of valence was only significant for AY trials,  $F(1, 20) = 6.22$ ,  $p = .02$ , partial  $\eta^2 = .24$ , where more errors were made to sad AY stimuli (mean = 12.36%, SD = 2.09) as compared to happy AY stimuli (mean = 9.1%, SD = 1.69). The main effect of valence was not significant for BX and BY trials,  $F_s < 2.10$ ,  $p_s > .05$ . These effects are displayed in Figure 6.12 below.

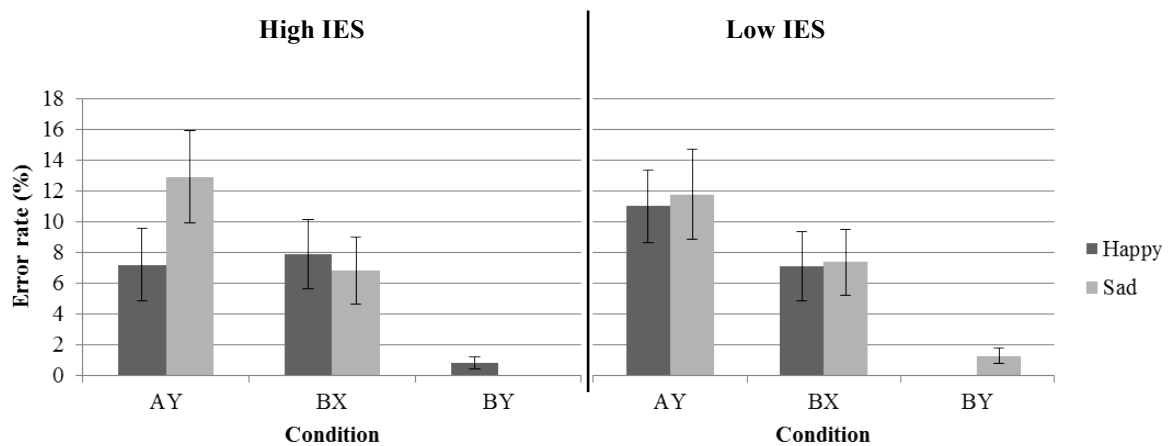


Figure 6.12. Mean error rates (with standard error bars) for ‘non-target’ trials, split by high and low IES group.

### Stroop task:

Stroop task performance did not differ on the basis of any of the between-group comparisons, in either the reaction time or error data. On each of the intrusive memory measures and the other self-report questionnaires, high and low groups

performed similarly on the task. Table 6.6 and 6.7 below display these F-values for the Stroop task, for reaction times and error rates respectively.

Table 6.6

*F-values for reaction times in the Stroop task. No F-values were significant.*

	Retro1	Retro2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.01	0.86	0.28	0.01	0.18	0.13	1.17
<b>Group x SAT</b>	0.01	0.45	0.01	1.52	0.45	0.90	0.10
<b>Group x compatibility</b>	0.54	0.23	0.21	0.04	0.51	0.45	0.31
<b>Group x SAT x compatibility</b>	0.36	0.03	0.01	0.29	0.65	2.08	3.27

Table 6.7

*F-values for error rates in the Stroop task. No F-values were significant.*

	Retro1	Retro2	Diary	IES	RRS	BDI-II	Extreme BDI-II
<b>Group</b>	0.10	0.01	0.16	0.13	0.29	1.45	0.04
<b>Group x SAT</b>	0.09	0.11	0.44	0.10	1.09	0.06	0.01
<b>Group x compatibility</b>	0.01	0.01	0.70	0.58	1.11	0.49	0.56
<b>Group x SAT x compatibility</b>	0.98	1.77	0.78	0.08	1.57	0.13	0.05

### 3) Correlations between self-report questionnaires:

The correlations between the questionnaire measures are presented in the matrix below, see Table 6.8. Firstly, there was a significant positive correlation between the two retrospective frequency measures; participants who reported a higher number of intrusive memories in relation to one specific previous event, as per Kvavilashvili (2014), also reported more intrusive memories overall during the Intrusive Memory Interview. In addition, the relationship between the frequency of both retrospective measures and IES scores was significant; the more times the participants experienced the intrusive/negative involuntary memory, the higher the level of subjective distress they also reported. Additionally, participants higher in trait rumination reported more intrusive memory-related distress. The correlation between IES and BDI-II scores was also significant, in that the higher the depressive symptomatology, the higher the intrusion-related distress. The significant correlation between RRS and BDI-II is

consistent both with our previous research (chapter 4, chapter 5) and a wealth of existing research (Nolen-Hoeksema, 1991; Nolen-Hoeksema et al., 2008; Spasojević & Alloy, 2001), demonstrating that rumination is a maladaptive response to low mood. Furthermore, the significant correlations are once again evidence that there was variation in the sample. Figure 6.13 displays the significant correlations below the table.

Table 6.8

*Correlation matrix displaying the correlations between the questionnaire measures. Significant correlations are presented in Figure 16.*

	Measure	Retro 1	Retro 2	Diary	IES	RRS	BDI-II
1	<b>Retro 1</b>						
2	<b>Retro 2</b>	.81 **					
3	<b>Diary</b>	.21	.26				
4	<b>IES</b>	.34 *	.43 **	-.16			
5	<b>RRS</b>	.03	.10	-.17	.32 *		
6	<b>BDI-II</b>	.12	.13	.12	.45 **	.45 **	

\*\*  $p < .01$ , \*  $p < .05$ , (\*)  $p < .10$

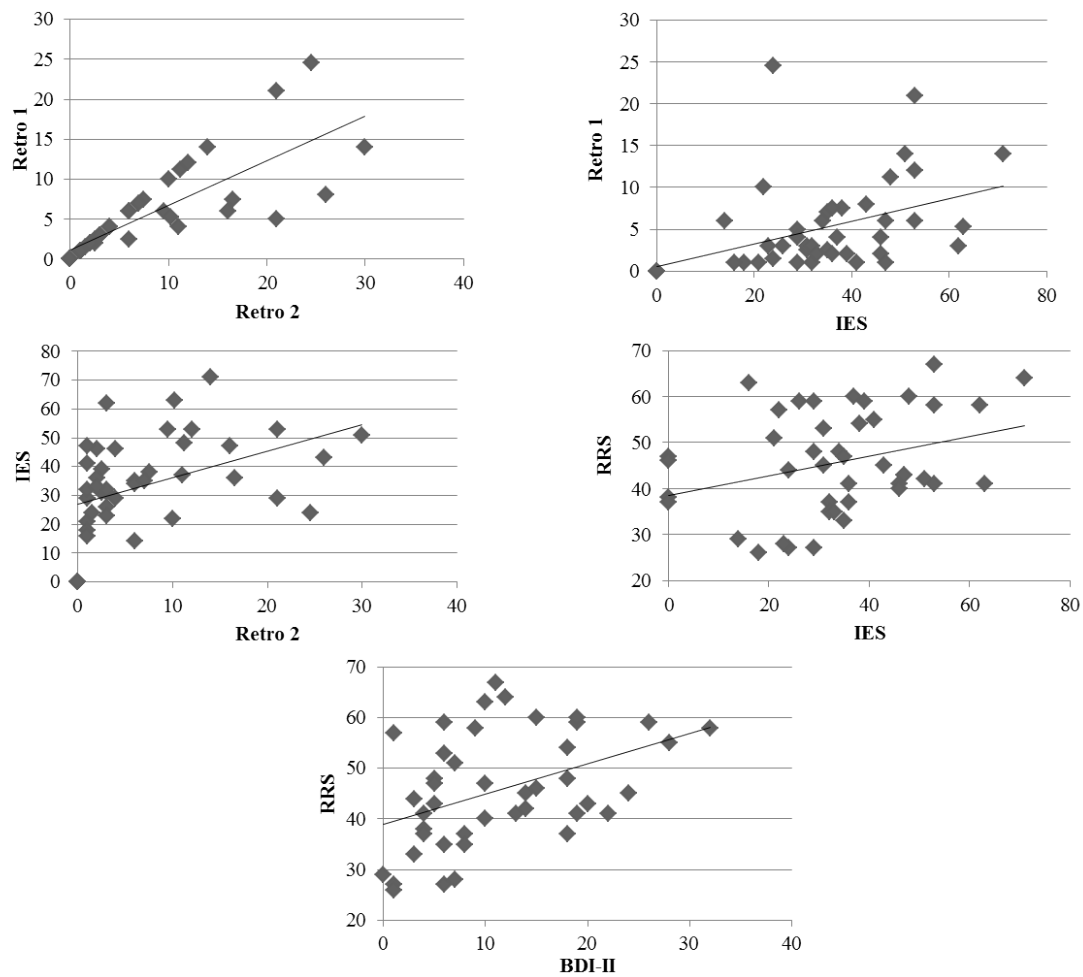


Figure 6.13. Displaying the significant correlations on the self-report measures

## Discussion:

The current study aimed to examine the role of cognitive control in intrusive memory vulnerability, using emotional tasks to extend upon the studies presented earlier in the thesis. This modification was done to ensure that the lack of cognitive control deficits found in these previous studies was not simply the result of the non-emotional stimuli used. This consideration was based upon research investigating cognitive control deficits as a function of depressive symptomatology, which has shown that individuals with depression show deficits when the cognitive control tasks involve emotional material (Gotlib & Joormann, 2010; Joormann, Hertel, Brozovich, & Gotlib, 2005; Joormann et al., 2011). No previous research has used emotional tasks

to investigate a potential link between cognitive control and intrusive memory experience. However, because intrusive memories have been highlighted as a feature of depression (Kandris & Moulds, 2008; Kuyken & Brewin, 1994; Kuyken & Brewin, 1999), and because they relate specifically to negative material, it was deemed important to assess performance in respect to emotional cognitive control, for both positive and negative stimuli. Consequently, the study investigated whether individuals who experienced a high number of intrusive memories were differentially affected by irrelevant happy or sad stimuli than individuals experiencing fewer intrusive memories. As for the previous studies presented in the thesis, a thorough investigation of intrusion-memory experience was conducted, comprising of both frequency and consequence measures. In turn, frequency was measured in two ways, with retrospective and diary measures. This was to ensure the measures were as accurate as possible, and to cautiously distinguish between intrusive and negative involuntary memories in light of some of the ambiguity surrounding the distinctions between the two terms. This thorough investigation of memory experience is important, as it has consistently been shown that it is not the frequency of memories that is of most importance, but instead the way the individual reacts to the memory (Starr & Moulds, 2006; Williams & Moulds, 2008b).

Another modification was the extension of the long SOA, as compared to the previous studies presented in the thesis. This was an attempt to increase the sensitivity of the task to be able to uncover any performance differences between BX and BY trials, and brought the long SOA into line with existing research (Braver et al., 2001; Msetfi et al., 2009). This change did impact participants' performance; in the long SOA conditions, participants were slower in both 'target' and 'non-target' trials and made



more errors in ‘target’ trials. This is opposed to chapters four and five, where participants responded faster and made fewer errors in the long SOA trials, and suggests that participants were influenced by the requirement to maintain context over a long duration period, as predicted by the DMC (Braver et al., 2007). This model states that, when the duration between the cue and target reaches a certain point, proactive control will not always be the optimal mode of control, due to the cost of context maintenance. Therefore, this finding is in support of the DMC, as the theory is eloquently able to account for these changes in behaviour, both within tasks and between populations (Braver et al., 2007, 2009; Speer, Jacoby & Braver, 2003). However, this effect of SOA did not interact with condition, i.e. performance was not selectively impaired for trials with the target letter X, where the response is ambiguous, as compared to the target letter Y, where the target letter indicates a ‘non-target’ response is appropriate.

A variety of between-group differences emerged on the AX-CPT, on both ‘target’ and ‘non-target’ trials. Of these, the most interesting was the effect of IES group. While reaction times in the low IES group did not differ between BX as compared to BY trials, the high IES group responded significantly more slowly to BX trials than to BY trials. This suggests that the high IES group were more influenced by the target-letter than the low IES group, who were able to use the B cue to prepare a ‘non-target’ response. This suggests a specific deficit in proactive control in individuals who report high levels of intrusive memory distress, specifically that they were less able to use context to prepare or maintain behaviour. In addition, the high IES group made significantly more errors to AY trials with sad stimuli, as compared to AY trials with happy stimuli, suggesting that they were impaired by the negative stimuli. As these

effects were not found in chapter four which use the same IES measure, but an unvalenced task, it suggests that future research should use emotional tasks of cognitive control to best uncover intrusive-memory related deficits in cognitive control. These results are initial evidence that individuals experiencing high levels of intrusive-memory related distress show some deficits in cognitive control.

Looking at the other findings that emerged, the significant effects that emerged on the ‘target’ trials reflected that the high diary group made significantly more errors to sad stimuli than to happy stimuli, where there was no effect of valence in the low diary group. This is another interesting finding which suggests that individuals experiencing more negative involuntary memories are more affected by irrelevant negative stimuli than individuals who do not experience so many memories; further evidence for a deficit in cognitive control. Again, this highlights the importance of using emotional tasks to look at potential cognitive deficits in this sample. Also on the diary group categorization, the effects of valence and SOA affected the high and low groups differently. Specifically, it was found that on the AY trials, the low diary group made more errors for sad stimuli with a short SOA as compared to sad stimuli for with a long SOA, whereas this effect was reversed for happy stimuli. It is unclear what this finding reflects, as it is not in the direction that was predicted. These unexpected findings highlight the need to be cautious when interpreting the findings that were as predicted. In particular, it must be noted in the interpretation of the valence x SOA interactions that, in light of the number of potential trial types (given that each cue-target pair was presented with both of the two SOA and valence options), the strength of these interactions is relatively weak. It would be important to replicate these findings in a design with more trial types, and with more participants, before drawing any strong conclusions. However, given some earlier issues with the AX-CPT in

chapters four and five, it was deemed important for the current study to also use the emotional Stroop task as a measure of cognitive control. This limited the feasible duration of the emotional AX-CPT task. The same limitations apply to the valence x SOA interactions found in the ‘non-target’ trials. These findings reflected that the group reporting a low number of intrusive memories were more slowed by the long SOA in the happy stimuli, as compared to the sad stimuli. It is unclear why this was the case. In the meantime, the findings of the current study reflect some indication that there is some link between intrusive and negative involuntary memory experience and cognitive control.

The other between-group effects were related to depressive symptomatology, as measured by the BDI-II. Crucially, these effects were only found in the extreme BDI-II group categorization, and not in the traditional mean split analysis. For the ‘target’ trials, the differential impact of valence on SOA was only significant in the low extreme BDI-II group, who showed a larger slowing in the long SOA for sad stimuli, as compared to the effect of SOA on happy stimuli. This, contrary to what would be predicted by previous research into the impact of depressive symptomatology on cognition (Gotlib & Joormann, 2010), suggests that the low extreme BDI-II group were *more* affected by the irrelevant negative stimuli than the high extreme BDI-II group. The other effect of extreme BDI-II group reflected that the high extreme BDI-II were particularly slowed on the long SOA AY trials (as compared to AY trials with a short SOA), whereas the SOA x condition interaction was not significant in the low extreme BDI-II. Again, this is an interesting finding as it suggests a specific depressive-related impairment in context maintenance. As previously discussed, this supports existing research using the AX-CPT (Msetfi et al., 2009). The focus on

depressive symptomatology was only secondary to the focus on intrusive memory, therefore no low mood criteria was used in participant recruitment. However, given the effects of BDI-II were only found in the more extreme analysis, future research focusing on depressive symptomatology should use this cut-off criterion. Msetfi et al. (2009) only looked at the impact of mild depression (BDI-II scores  $\geq 9$ ) on task performance, whereas the criteria for the high group on the extreme categorization used in the current study was a score  $\geq 17$ . This score, according to the original BDI-II manual reflects a high true-positive rate (Beck et al., 1996), and is also consistent with previous research (Saunders & Jentsch, 2014). It would be useful for future work to continue to use the emotional version of the task to further explore these deficits.

Performance on the emotional Stroop was also used to index proactive and reactive control processing. They were reflected through the impact of speed-accuracy instructions, and through Conflict Sequence Effects (CSEs), respectively. On the Stroop task, participants demonstrated proactive control by effectively using the instruction at the beginning of the block to adapt their behaviour; responding faster under speed instructions and more accurately under accurate instructions. However, contrary to predictions, there was no effect of previous trial compatibility on current trial performance; the classic Stroop effect was not reduced after an incompatible trial as compared to a compatible trial. This meant there was no measure of reactive control in this task either, although it is unclear why this was the case. One interesting possibility pertains to the recruitment criteria used in the study advertisements. The specific wording of the advert was for individuals who had recently experienced intrusive memories, rather than not including any memory-

related requirement. This may have resulted in a sample selection bias, and resulted in only participants who experience a high number of memories taking part, rather than gaining a true picture of general intrusive/negative involuntary memory experience across a general sample. Consequently, *all* participants may have been characterized by a deficit in reactive control, which would explain the lack of CSE in the current data set. It is important to remove this requirement from the advertisement to investigate this possible explanation.

In terms of group comparisons on the Stroop task, no differences in the ability to modify behaviour based on instruction were found. This suggests that individuals who experience a high number of intrusive and negative involuntary memories (indexed either via frequency and consequences measures) do not show proactive control impairments. There were also no differences in task performance as a function of depressive symptomatology; high and low BDI-II participants performed similarly on the task. The lack of a depressive related deficit in proactive control parallels Saunders and Jentsch (2014), who found participants high in BDI-II scores were able to make the same speed/accuracy adjustments as participants low in BDI-II scores, on both the classic and emotional Stroop task. In the same study, they demonstrated that reactive control was impaired in high BDI-II participants in the emotional, but not the classic, Stroop. Specifically, high BDI-II participants showed reduced CSEs (i.e. a reduced ability to adapt behaviour after high conflict) compared to low and medium BDI-II groups. However, as was no overall CSE in the current study, it is unclear whether this selective reactive deficit extends from depressive symptomatology to intrusive memory experience. Although Verwoerd et al. (2009) also found no deficits in Stroop performance in relation to measures of intrusive-memory experience, this

was only investigated with the *classic* Stroop task. As previously argued, existing research suggests the importance of assessing emotional task performance in terms of establishing depressive-related deficits (Joormann et al., 2011; Koster et al., 2005), therefore it was important to extend on this finding with an emotional Stroop task, to determine whether the use of an emotional task was more sensitive at detecting intrusive-memory related deficits. However, no between-group differences were found in terms of the ability to modify behaviour based on instruction during the Stroop task, and neither of the groups were differentially affected by the compatibility of the stimuli. This suggests against the idea that people experience more, or suffer more from, memories for negative past events that they did not deliberately recall are characterized by deficits in cognitive control.

In conclusion, the current study was conducted to address some of the limitations of the studies presented in the preceding two chapters, most critically by including emotional stimuli, addressing the relatively short long SOA used previously and by using different measures of proactive and reactive control. The importance of using emotional stimuli was supported by the findings that did emerge in this study. In comparison to the lack of the overall intrusive and involuntary memory-related deficits found previously in the thesis, some behavioural RT comparisons were significant. Although the findings were not clear-cut, the findings do support that the addition of valence to the task was important and made the task more sensitive. Most interestingly, the finding that the high IES group did show significantly poorer performance on BX trials compared to BY trials, where in both cases the cue letter B had already indicated that a ‘non-target’ response was required. In addition, the change to the SOA did affect performance. In this case, participants were slower and

made more errors in the long SOA trials. Despite this, there was still no difference in RTs between BX and BY trials. Importantly, this shift in behaviour as the result of the extended duration between cue and target does support a dual mechanisms account of cognitive control (Braver et al., 2007). Consistent with the other two studies presented here, this BX/BY difference was found in the error data; more errors were made in BX trials as compared to BY trials. This is an important characteristic of the task. However, the lack of RT difference, even with those adaptations to the methodology, does highlight limitations of the task. It could be too simple for the sample tested, a conclusion that will be further discussed in the subsequent final discussion chapter. These discussed limitations of the AX-CPT provided the rationale for also looking at Stroop task performance in the current study. However, there were no deficits in Stroop task performance on any of the between-group comparisons. It must be noted that conclusions about Stroop performance are hampered by the lack of CSEs in the data. Nonetheless, it can tentatively be concluded that this is evidence that intrusive-memory deficits do not emerge on all emotional tasks.

Overall, the results of the current research do suggest that future research into intrusive and involuntary memory vulnerability should continue to use emotional stimuli in the tasks. This is perhaps an especially important consideration when using non-clinical samples to establish basic mechanisms underlying intrusive memories, as it appears to make the AX-CPT task as sensitive as possible to any individual differences. The subsequent closing chapter will discuss the limitations of the current design, and draw together conclusions emerging across the three studies into cognitive control.





# **Chapter seven.**

## **Discussion.**

The aim of the present thesis was to build upon existing research into intrusive memories in depression. Once considered specific to Post-Traumatic Stress Disorder (PTSD), individuals with depression also experience intrusive memories (Brewin et al., 1996b; Kuyken & Brewin, 1994). Intrusive memories refer to past negative autobiographical events, and come to mind without having been deliberately recalled (Hackmann et al., 2004). Contrary to the traumatic nature of intrusions in PTSD, the content of intrusive memories experienced by individuals with depression primarily concerns interpersonal events, for example arguments or relationship break-ups (Moulds & Krasn, 2015), past failings (Newby & Moulds, 2012), loss of employment or death of others (Brewin et al., 1996b). Importantly, depressed individuals have been demonstrated to appraise their intrusive memories in a negative way for example ‘having this memory means there is something wrong with me’ (Moulds et al., 2008). These maladaptive responses increase distress (Starr & Moulds, 2006; Williams & Moulds, 2008b) and contribute to the maintenance of low mood over time (Newby & Moulds, 2011c). For example, distress may encourage avoidance behaviours, including thought suppression and rumination, which further increase the distress experienced (Ehlers & Steil, 1995; Moulds et al., 2008). Therefore, a considerable amount of research has focused on factors that are important after the experience of intrusive memories, including the importance of these maladaptive responses. The primary aim of the thesis, however, was to look at why these intrusive memories come to mind in the first place. As intrusive memories are memories that have not been deliberately recalled, or memories that come to mind when we do not want them to, it has been suggested that the experience of intrusive memories may be related to individual differences in cognitive control (Bomyea et al., 2012). Therefore, three studies looked at a potential link between cognitive control and intrusive memory

experience, using the Dual Mechanisms of Cognitive Control (DMC) framework (Braver et al., 2007). Despite growing support for the DMC, existing research into cognitive deficits in relation to intrusive memory experience has not distinguished between proactive and reactive control. Therefore, the goal of the current thesis was to determine whether intrusive memories are experienced as a result of impaired cognitive control, and if so which aspect of cognitive control, proactive or reactive, is affected. A further goal was to include emotional cognitive control tasks, specifically the emotional AX-CPT and the emotional-face Stroop. Most of the existing research examining a link between intrusive memory experience and deficits in cognitive control has not used tasks that feature emotional stimuli. However, it is important to include an emotional component into the measure of cognitive control, as intrusive memories explicitly relate to a *negative* life event. Consequently, individuals who experience a high number of these memories may display a specific deficit on a task that includes negative emotional information. One example of intrusive memory research which has used a task with an emotional component is the Colour Naming Interference Task used by Wessel et al. (2008) in their investigation of film-induced intrusive memories. This task included both positive and negative film-related words. They found that a lower level of interference on the task was related to better performance on a Random Number Generator task, which was used as a measure of individual updating/monitoring abilities. This supports the idea that good updating/monitoring plays a role in reducing interference from stressful life events, in this case watching a stressful film-clip. Importantly, however, performance on the colour-naming interference task was *not* directly related to indices of intrusive memory experience; it was only related to updating/monitoring abilities. Therefore, the current thesis aimed to further investigate performance on a cognitive control task

with an emotional component. Another important goal of the current thesis was to extend the investigation from potential cognitive control deficits and intrusive memories, to look more generally at all kinds of involuntary memories, which can be positive, negative or neutral. This aim was consistent with recent commentary about the importance of bridging the gap between clinically-focused literature, which has focused almost exclusively on negative intrusive memories, and research into involuntary memories more generally (Moulds & Krasner, 2015). Crucially, the involuntary memory literature has demonstrated that involuntary memories are common, although the specific frequency varies between individuals and over time (Berntsen, 2011). Most importantly, these memories are often about positive (Berntsen, 1998; Berntsen & Hall, 2004), or not particularly important life-events (Berntsen, 2001), rather than being exclusively about traumatic or highly stressful life events (Berntsen & Rubin, 2008). Therefore, starting with the assumption that involuntary memories are always problematic is not theoretically justified. Accordingly, Rasmussen and Berntsen (2009) reason that while these memories may become problematic if experienced on a regular basis, or if they relate to a particularly stressful event, it does not necessarily follow that the mechanisms underlying involuntary memories are fundamentally maladaptive. This argument has consequences for research looking at a potential connection between deficits in cognitive control and intrusive memory experience; the impact of cognitive control may not depend on the valence of the memory. The study presented in chapter five was the first study to use a task to measure cognitive control when looking at involuntary memory experience and cognitive control. Previous research has focused on how the experience of involuntary memory related to self-report measures of cognitive failures (Kamiya, 2014; Verwoerd & Wessel, 2007).

Given that the exact relationships between intrusive and involuntary memories remains to be established, as discussed in the introduction chapter, a cautious approach was taken in the current programme of research. In line with previous research, the Intrusive Memory Interview (Hackmann et al., 2004) was used to measure what was then described as an *intrusive* memory. However, the memories recorded in the diary were more generally referred to as negative involuntary memories. These memories could refer to any past event that came to mind without being deliberately recalled during the study procedure, rather than concerning the same original event.

Results of the cognitive control research will now be briefly recapped and interpreted in relation to previous research, before limitations and ideas for future direction are presented. In terms of cognitive control, using the traditional AX-CPT, contrary to predictions, there were significant findings. In chapter four, there was an indication on the error data analysis that individuals reporting a high number of negative involuntary memories demonstrated a deficit in proactive control. This suggests that experiencing a high number of negative unrecalled memories interferes with the ability to accurately maintain contextual information. In chapter five, which examined all types of involuntary memories, there was a similar finding on the consequence measure of involuntary memory experience, specifically on the measure of rumination. High ruminators made more errors to trials with a long SOA, compared to trials with a short SOA. In this case, rumination was used as a measure of trait tendencies to get stuck on negative cognitions, such as negative involuntary memories, or feelings of low mood. Therefore, this finding is an indication that individuals who *suffer* more from their involuntary memories show a deficit in

proactive control. The other effects that were found in the involuntary memory chapter were related to the extreme BDI-II group categorization. Contrary to predictions, individuals high in depressive symptomatology ( $BDI-II \geq 17$ ) were better at maintaining context on non-target trials than individuals low in depressive symptomatology. This finding contradicts research by Msetfi et al. (2009), who found that the high BDI-II group ( $BDI-II > 9$ ) showed a deficit in context maintenance. Methodological differences between chapter five and Msetfi et al. (2009) that may explain this discrepancy have already been discussed, but it is important to note that this finding was not found in the other study in this thesis (chapter four) that used the AX-CPT. Therefore it is unclear how reliable this finding is. Another finding from the final study which looked at emotional AX-CPT performance was that the high extreme BDI-II were more conservative than the low extreme BDI-II group (i.e. were slower but made fewer errors) in their responses for non-target trials. It must be highlighted that there were some issues with the measure of reactive control in these earlier chapters. In terms of overall reaction time (RT) performance, participants were not impaired by the letter X in BX trials. This suggests they could always fully make use of the cue-letter information to already prepare a 'non-target' response in cue-letter B trials. This was probably the result of a relatively short long duration period between the two letters, which made the task too easy. However, as predicted, significantly more errors were made to BX trials than to BY trials. This demonstrates that participants do sometimes engage in target-letter processing (Braver et al., 2007); information from the cue was not always fully used to prevent an error. However, as this difference was not found in the RT data, conclusions about potential deficits in reactive control awaited methodological adjustments to the task, specifically an extension of the long duration period. Although these changes were subsequently

made in the final study, there was still no significant difference in RTs for BX compared to BY trials. This suggests the previous non-significant BX/BY difference was not wholly attributable to the short duration period between letters. This is further evidence that the task was possibly too easy for the sample of participants tested. In addition to the repeated-measures ANOVAs used in the current data analysis, some of the previous work using the AX-CPT has also used signal detection measures of sensitivity ( $d'$ -context) to analyse error data. This method compares hit rates to AX trials to false alarms to BX trials, and is taken to be a more specific measure of sensitivity to context (Cohen, Barch, Carter, & Servan-Schreiber, 1999). Participants tested in the current research did not make a high enough number of errors to make this analysis meaningful (total error rates for AX trials were at < 5% and total error rates for BX trials < 8% across all four studies). One possible way to increase the number of errors would be to provide a specific response window after the target letter is presented, as done by Msetfi et al. (2009), who gave participants 1000 ms to respond. This may make the task more sensitive in a young, healthy sample and consequently indicate a stronger link between impaired cognitive control and intrusive or involuntary memory experience.

Other findings from the emotional version of AX-CPT were more supportive of predictions. Specifically, individuals reporting higher memory-distress and higher memory-avoidance, as measured by the Impact of Event Scale (IES), showed a deficit in proactive control. The IES was used to measure detrimental consequences of the memory. Therefore, this finding can be interpreted in respect to the suggestion by Braver (2012) that ruminative processes interfere with context maintenance because attentional resources are taken-away from task-specific resources. In the case, it is

specifically higher levels of intrusive-memory distress, rather than trait rumination, that is associated with a deficit in cognitive control. Because the significant effect emerged on the measure of memory consequence, rather than on the measure of memory frequency, results are also consistent with existing research highlighting the importance of reactions to the memory, rather than the actual frequency of the memory per se (Moulds et al., 2008; Starr & Moulds, 2006; Williams & Moulds, 2008b). This finding extends the role of distress in intrusive memory maintenance to the initial manifestation of the memory; it is higher distress, rather than higher frequency, that is associated with a deficit in proactive cognitive control. Therefore, future research should take both frequency and consequence of the memory measures into account. Another important finding was that, on the error rates for ‘target’ trials, individuals who reported high numbers of negative involuntary memories in the diary were more negatively impacted by negative stimuli than positive stimuli. This suggests a specific valence-dependent deficit in the ability to ignore irrelevant emotional material in these participants. It is interesting that both intrusive/negative involuntary memory frequency findings pertained to the *diary* measure of intrusive memories. Although, as will be discussed below, there are potential issues with the accuracy of diary measure, the current findings do suggest that the diary is the most sensitive frequency measure in terms of determining individual differences in cognitive control. This programme of research reflected the first application of the DMC to intrusive memory research and found some evidence for a deficit in proactive control as a function of intrusive or involuntary memory experience. Existing research has focused specifically on the role of proactive interference and has demonstrated an association between low levels of resistance to proactive interference and high levels of intrusive memories (Verwoerd et al., 2009; Verwoerd et al., 2011). Although this



previous research has successfully focused on one specific component of cognitive control, the Dual Mechanisms of Control (DMC) was used as the framework for the current research because it addresses the *flexibility* of cognitive control. Therefore the current demonstration of a deficit in proactive control on both the IES and on the diary measure, considered in conjunction with the findings of previous research, suggest that there is some link between the experience of memories that are not deliberately recalled and individual differences in cognitive control. However, it is important to recognise the limitations of the current findings. Across the thesis, the sample sizes were relatively small and there were a number of statistical comparisons made for each set of task data. This increases the probability of making a Type I error, i.e. finding a “false positive”. Alpha corrections were applied to post-hoc comparisons only. Therefore, it is important to try and replicate the findings in a much larger data set, where alpha corrections can be made to all between-subjects comparisons, and using a more sensitive task than the AX-CPT. This limitation is particularly important in the final study, where not all findings were in the predicted directions (e.g. participants in the low diary group were more negatively impacted by the sad stimuli than the happy stimuli, whereas this was not the case for the high diary group). These unexpected findings underline the importance of being cautious about the strength of the findings that were in line with predictions; again, it would be important to establish a more consistent pattern of memory-related deficits before drawing any concrete conclusions. An important message emerging from the final study pertains to the importance of using the emotional version of the AX-CPT as the most sensitive way of uncovering individual differences in cognitive control that are linked to intrusive memories. This finding is consistent with existing literature looking at the general effect of depression on cognitive control, which has found that depressive-

related deficits most consistently emerge when tasks require the processing of emotional material (Gotlib & Joormann, 2010; Joormann et al., 2005; Joormann et al., 2011). However, it is important to note that there were no significant differences between the groups on the emotional-Stroop task. Therefore, intrusive memory related deficits do not emerge on all cognitive control tasks with an emotional aspect. The Stroop specifically measures response inhibition; the ability to override automatically triggered responses when they are not appropriate (Verwoerd et al., 2009). Consequently, the lack of between-group differences does not lend support for the idea that there is a link between intrusive memory experience and response inhibition abilities. Verwoerd et al. (2009) also found that there was no relationship between performance on the classic Stroop task and intrusive memories of a stressful event in student participants, using regression analysis. This previous work by Verwoerd et al. (2009) was extended to include the emotional Stroop task, as it was argued that deficits might emerge on a task that included irrelevant emotional material. However, this was not the case and is further evidence that there is no relationship between intrusive memories and response inhibition, as assessed by the Stroop. Furthermore, in light of the contradictory results of the emotional AX-CPT and emotional Stroop tasks, future research should continue to use emotional tasks that rely on different components of cognitive control in order to provide a clearer indication of intrusive or involuntary memory-related deficits.

While the studies presented here provide at least some indication that there is a link between cognitive control and intrusive memory experience, it is important to highlight the limitations of the work. One potential issue relates to the non-clinical student and community sample used throughout the thesis. Notably, these samples are

consistent with the type of samples used in existing research into both intrusive memories in depression generally (Starr & Moulds, 2006; Williams & Moulds, 2008b), as well as research looking specifically at cognitive control and intrusive memories (Verwoerd et al., 2009; Verwoerd et al., 2011; Wessel et al., 2010). Non-clinical participants, performing on a continuum across a particular clinical diagnostic measure, are often used in experimental cognitive psychology to initially investigate any basic effects. For example, student and community samples have been used to investigate the relationship between rumination and depression (Nolen-Hoeksema, 1991; Nolen-Hoeksema et al., 1993), between depression and overgeneral memory (Gibbs, 2004; Smets, Griffith, Wessel, Walschaerts, & Raes, 2013), and between problem solving, depression and rumination (Dennis, Astell, & Dritschel, 2012; Kao, Dritschel, & Astell, 2006). As advocated by Brewin (1998), the primary overarching aim of this kind of non-clinical research is to establish any basic effects in a non-clinical sample, with the view to later try and generalise findings to clinical samples. However, there is a well-known criticism of the use of undergraduate student samples in behavioural sciences, which highlights the dangers of making wider inferences on the basis of results from this highly specific Western and highly educated sample (Henrich, Heine, & Norenzayan, 2010). In addition, it could be argued that the lack of significant between-group differences in the cognitive control studies may reflect a lack of variation within the sample. It could be the case that all individuals are too high functioning and that there was an issue with ceiling effects on the task. This may, for example, explain the lack of difference in RTs between BX and BY trials; participants all used proactive control effectively to engage in cue-based processing and, as a consequence, there was not enough variation to find significant differences in reactive control. Another potential issue is that the sample was non-clinical. As

such, it could be argued that the intrusive memories participants experienced were perhaps not as distressing or as debilitating as memories reported by a less healthy sample, and therefore perhaps the same underlying effects do not apply to memories experienced by clinical populations. However, in response to these criticisms, it must be noted that this sample is consistent with previous research that did find performance differences as a function of intrusive memory experience, specifically in relation to proactive interference abilities (Verwoerd et al., 2008; Verwoerd et al., 2009) and in terms of more general measures of attentional control (Verwoerd et al., 2008; Wessel et al., 2008). Consequently, the lack of clear effects found in the current research cannot simply be attributed to the type of participants that were tested. In fact, scores on the self-report measures suggest that the current sample was actually characterized by higher intrusive-memory distress than reported in this previous research. For example, when looking at proactive interference, Verwoerd et al. (2009) reported the mean IES score for intrusive memories of most distressing event participants had ever experienced to be 14.11 (SD = 13.48). This mean is substantially lower than the mean IES scores in the current programme of research, which were 33.34 (SD = 13.49) in chapter four, and 33.67 (SD = 16.75) in chapter six. These comparisons further support the idea that some of the null findings in chapters four and five are not simply an artefact of the sample tested. In fact, these scores actually seem more similar to Horowitz et al. (1979) who reported that the mean IES scores in a clinical outpatient sample was 39.5 (SD = 17.2). Nonetheless, it must be noted that the mean scores on the BDI-II, which was used as a measure of depressive symptomatology, were low in the current sample. Across the cognitive control studies, the mean BDI-II ranged from 9.23 (SD = 5.65) to 13.49 (SD = 9.08), and for the intervention study, which specifically recruited low mood participants, the mean

BDI-II score was 20.44 (SD = 14.85). To put this into context, the original BDI-II manual (Beck et al., 1996) cites scores between 0-13 as indication of no or minimal depression, scores between 14-19 as indicative of mild depression, scores between 20-28 as moderate depression, and scores above 29 as indicative of severe depression. Therefore, the mean BDI-II scores of participants tested in the current research are low. To counteract the criticism surrounding using mean splits, the current research also looked at extreme BDI-II data. While this is advantageous because there are more clearly defined differences between the low and high groups, it does mean that sample sizes are somewhat diminished. Consistent with past research (Saunders & Jentzsch, 2014), scores above 17 were included in the high group as this, according to the BDI-II manual, reflects a high true-positive rate for clinical levels of depression (Beck et al., 1996). However, it might be argued that this is still a relatively low score to perform the split at, given the maximum total score on the questionnaire is 63. Across the three cognitive control studies, the range of the high extreme BDI-II scores were still only between 17-32. Nonetheless, once again it can be argued that this sample is consistent with the previous research into intrusive memory experience as a function of individual differences in cognitive control. Verwoerd et al. (2009) and Verwoerd et al. (2011) both used the Center for Epidemiologic Studies Depression Scale (CES-D) Scale. Although scores on the CES-D are not directly comparable to the BDI-II scores collected in the current research, the mean CES-D scores of participants in this previous research were 11.53 (SD = 9.24) and 7.1 (SD = 6.9) respectively. Radloff (1977) suggest that scores above 16 on the CES-D should be used as cut-off point for high levels of depressive symptomatology, therefore, it can be concluded that scores collected in the research by Verwoerd and colleagues also reflect quite a low endorsement of symptoms of depression.

An additional limitation of the current cognitive control research is potential recruitment biases, because the adverts sought individuals who ‘have recently experienced intrusive/involuntary memories’. This specification was used to ensure that participants were able to notice and report on their experience of intrusive and involuntary memories. However, this may have resulted in frequency estimates being artificially inflated, with only very few participants experiencing no or very low numbers of intrusive or involuntary memories. This in turn may have reduced the ability of the design to find significant group differences, as all participants may have been characterized by some degree of cognitive deficit. This could, for example, be an explanation for why there was no conflict sequence effect (CSE) in the Stroop task presented in chapter six. Contrary to predictions, and contrary to previous research (Gratton et al., 1992; Holmes & Pizzagalli, 2007; Saunders & Jentsch, 2014), participants did not make on-line performance adjustments in response to conflict. However, given the selection criteria outlined in the advert, which meant all participants were experiencing unrecalled memories to some extent, this lack of adjustment may reflect that *all* of the current participants were characterized by a reduced ability to modify their behaviour based on previous experiences of conflict. This would specifically reflect a deficit in post-interference reactive control (Braver et al., 2007), as has previously been demonstrated in participants with high levels of depressive symptomatology (Holmes & Pizzagalli, 2007; Saunders & Jentsch, 2014). It must be noted that, despite the wording of the advert, for the intrusive memory chapters, there were two or three participants who did report zero intrusive memories on either the retrospective, diary, or on both measures. Conversely, there were no participants who recorded zero memories in the involuntary memory chapter.

In terms of the intrusive memory study, the data from the participants reporting zero memories was still included in the analysis. This would have reduced the potentially inflated overall mean number of memories. However, it is important to address this issue in subsequent research. Removing any mention of previous intrusive or involuntary memory experience from the recruitment procedure would ensure an accurate picture of everyday experiences of intrusive or involuntary memories was attained. This would potentially uncover individual differences in cognitive control between people who experience no intrusive or involuntary memories, as compared to individuals who experience either a low or high numbers of intrusive or involuntary memories.

Another potential criticism of the studies presented is the use of mean splits to establish the high and low groups for each of the dependent variables. This method of analysing the data were used for practical reasons, as it makes a continuous variable suitable for an ANOVA-based analysis. In addition, data from all participants is included in the analysis, rather than excluding participants with ‘medium’ scores as done in some previous research to accentuate group differences (Compton et al., 2008; Watson et al., 2008). However, this form of dichotomization, such as mean or median splits, has been criticised (MacCallum, Zhang, Preacher, & Rucker, 2002; Streiner, 2002). The biggest problem with splitting data this way is that similar scores will be grouped differently if they fall close to the cut-off value. The method also reduces statistical power. For example, Cohen (1983) demonstrates that dichotomising variables reduces power in a similar way to reducing sample size. This is especially problematic in light of the already relatively small number of participants tested in the present studies. With larger sample sizes, future research could use

regression analysis, such as used by Verwoerd and colleagues, to address the issues with the current method of data analysis. Another reason for using mean splits to analyse the current data set was that there are no clear guidelines on splitting the primary variables of interest into standardized groups, for example what constitutes a high or a low number of intrusive or involuntary memories. This is in contrast to the classification guidelines provided for BDI-II scores, as outlined above. A clearer picture of general experiences of these memories would be required for this type of predetermined group classification.

There are also some general issues concerning the accuracy of frequency assessments of both intrusive and involuntary memories. Previous reports of frequency, which provide a reference point for comparing frequency estimates from the current research, will now be summarized. Looking at intrusive memories reported through the Intrusive Memory Interview, Newby and Moulds (2011a) note that their currently depressed participants reported experiencing intrusive memories on 3.75 (SD = 2.57) days during a one-week period, the recovered depressed participants on 3.00 (SD = 2.41) days and never depressed on 2.79 (SD = 2.22) days. Within those days, the currently depressed experienced their memories 3.60 (SD = 3.68) times, the recovered depressed 1.92 (SD = 1.12) times, and the never depressed 1.43 (SD = 0.94) times. These numbers result in total frequency estimates over the week of 13.5 memories for the currently depressed, 6 memories for the recovered depressed and 4 memories in the control participants. As the sample tested in the thesis was non-clinical, participants were most similar to Newby and Moulds (2011a) control participants who reported 4 intrusive memories during the week. Therefore, the frequencies of intrusive memories in the current research, also measured by the Intrusive Memory



Interview (mean intrusive memories over the week= 4.99, SD = 5.13 and mean = 5.10, SD = 8.42 in chapters four and five respectively) are similar to this past research. When all memories reported on the Intrusive Memory Interview were considered in chapter six, the mean was 7.16 (SD = 7.85). In terms of the diary measure, which was taken as a more general measure of negative involuntary memories, frequencies were 2.46 (SD = 1.48) and 4.53 (SD = 4.01). These are lower than frequencies indicated by Newby et al. (2014) when testing the efficacy of cognitive bias modification and cognitive behavioural-based interventions as a treatment for problematic intrusive memories. Their control participants, who received no treatment, recorded a mean of 14.47 (SD = 12.19) intrusive memories over a 7-day period on their diary measure. These frequencies seem quite a bit higher than participants tested in current research. Potential issues with the accuracy of the diary measure will be discussed after current frequency involuntary memory estimates are compared to previous research. In terms of involuntary memories, while it is now established that they are common in daily life, there is little concrete evidence about their actual frequency (Rasmussen et al., 2015). Furthermore, as introduced in the methodology chapter, one key difference between the intrusive and involuntary memory literatures are the way memories are measured. Direct comparisons between the number of memories recorded in the retrospective and diary measures in the current research are not possible, as the two methods relate to two different time periods, either the week before or the week after participation in the study. However, in the context of the intrusive/negative involuntary memory distinction, it is interesting to note that in both the intrusive memory studies, the retrospective measures were *higher* than the diary measures. Kvavilashvili (2014) would argue that the diary measure is a more general measure of memory, as it includes a memory for

*any* negative past event that comes to mind during the recording period, whereas the Intrusive Memory Interview is a measure of one specific event. This finding may underline issues with the inaccuracy of diary methodology. Accordingly, there is some indication that different *ways* of measuring memory frequency can result in different estimates of frequency (Rasmussen et al., 2015). For example, accurately keeping a diary record of the memories may require too much effort for participants to completely adhere to the instructions. Previous discrepancies in memory frequency indications support this argument. Specifically, Schlagman and Kvavilashvili (2008) found that the mean number of memories recorded in a diary over a 7-day period was 10.05 (SD = 5.46, range = 1-25) in a diary over a 7-day period (sample size=44). Compared to this finding, it does appear that the diary frequencies of involuntary memories (mean = 4.53, SD = 4.01) were quite low in the current research. However, estimates of involuntary memory frequency provided by Rasmussen and Berntsen (2011), also in an undergraduate sample but when memories were indicated by pressing a mechanical counter, were substantially higher. In this study the mean number of memories recorded was 22.13 (SD = 16.74) over the course of a day (sample size = 48). The impact of the chosen recording procedure on the outcome of the frequency measure is further demonstrated by Rasmussen et al. (2015) who also tested undergraduate students. They showed a difference between frequency estimates gathered through a small mechanical counter and through a smartphone, which was used as an electronic diary. More specifically, when the frequency estimates were indexed through mechanical counters, involuntary memories were experienced over two and a half times as frequently over the period of one day (mean = 19.88, SD = 17.46) as voluntary memories (mean = 8.00, SD = 6.99), and this difference was significant. In a different study reported in the same paper, they compared the number

of involuntary and voluntary memories, this time recorded using a smartphone device. In this case, no significant difference was found between the number of involuntary (mean = 14.72, SD = 8.68) and the number of voluntary (mean = 10.32, SD = 7.85) memories recorded. The authors suggest this discrepancy may be a result of the additional effort required for the smartphone measure, as compared to simply pressing the mechanical counter. While a smartphone is small and can be easily kept to hand, it still has to be unlocked by a button press to make a recording after a memory is experienced. The authors argue that this additional effort to record the memory detrimentally affected records of involuntary memory more than voluntary memories because involuntary memories are more frequent, and are therefore more sensitive to the recording procedure. This suggestion was supported by a meta-analysis they conducted on data collected across four studies. Specifically, it was only in the involuntary memory condition, and not for voluntary memories, that there was a reduction in the number of memories recorded through the smartphone as compared to the mechanical counter. This supports the authors' prediction that involuntary memory records are more susceptible to increased demands of the recording procedure, simply due to the fact they are experienced more frequently. In conjunction, these results imply that when frequency is the focus of the study, the recording methodology should be minimally demanding. There is, nevertheless, a balance between gathering any type of important information about the memory, and trying to keep the recording methodology as reliable as possible. This trade-off was considered in the current design by only asking participants to answer a small number of questions about their memories, in a small convenient paper booklet. However, even this process may have been too time-consuming or awkward for participants to accurately record the number of memories they experienced, and may have

contributed to the low frequencies in the current data set. Consequently, it would be interesting to examine whether using a mechanical counter, instead of a diary measure, would vary frequency estimates enough to indicate a different link between memory experience and cognitive control. Another suggestion made by Rasmussen et al. (2015) is to look at whether shortening the period during which participants are asked to keep records of their memories increases the number of memories participants subsequently report. They base this suggestion on research by Kamiya (2014). In this study, participants walked around their university campus and recorded all involuntary memories they experienced during this time. Records were made by immediately alerting the experimenter who was walking slightly behind them with a tape recorder. The task lasted approximately one hour, but the mean number of memories reported was 12. As such, the number of involuntary memories experienced during this short walk was higher than the total number of memories reported in the diary by participants tested in chapter five over a whole week. This substantial discrepancy requires further investigation. It does further support the idea that the way involuntary memories are measured has an impact on what is recorded. Consequently, it would be interesting to rerun the current studies, but only asking participants to keep a diary, perhaps with fewer questions, over a period of three to four days. This methodological change would help determine if the low frequency estimates were somewhat the result of participant fatigue or non-compliance. Previous research that investigates the link between cognitive control and intrusive memories further suggests asking participants to record intrusive memories in a diary may impact the number of memories experienced. Specifically, Verwoerd et al. (2008) found that participants who kept a diary of film-related intrusive memories reported almost three times as many memories as participants who retrospectively rated their

intrusive memories about the film at the end of the week. The authors suggest that repeatedly having to remember to fill in the diary may increase the activation of the memory, and therefore artificially inflate the number of memories experienced. This high level of activation explanation may explain the high estimates of the Kamiya (2014) study. Although this finding relates to memories induced by film-clips, and not real-life intrusive memories, it is more evidence that the method used to collect information on the memories can impact frequency results. Together, these findings suggest that future research should carefully consider potential caveats to the specific measure that is used. Subsequent studies should also consider comparing different methodologies in a between-groups design to address potential implications of these discrepancies in terms of establishing a link between cognitive control and intrusive or involuntary memory experience. While there are some limitations to the conclusions that can be drawn from the work presented in these chapters, there are important reasons for continuing to investigate the link between cognitive control and intrusive memories. As argued throughout the thesis, understanding more about why some individuals experience higher numbers of unrecalled memories, or are more negatively affected by these memories, is crucial given the key role they have been shown to play in causing distress and sustaining depressive symptomatology (Newby & Moulds, 2010; Starr & Moulds, 2006; Williams & Moulds, 2008b). A clearer picture of cognitive deficits may also permit a more in-depth understanding of individuals at-risk for mental health problems following stressful life events. For example, there is some existing evidence that a predisposition to endorse negative appraisals predicts future mental health problems. Specifically, Bryant and Guthrie (2007) established that in trainee fire-fighters, a predisposition to endorse negative appraisals about themselves, for example 'I am a weak person' or 'I can't rely on

myself’ (Foa, Ehlers, Clark, Tolin, & Orsillo, 1999) accounted for 20% of the variance in PTSD symptomatology after they had been working as a fire-fighter for four years, during which time they had been exposed to many traumatic episodes. This suggests that pre-existing maladaptive appraisals are a risk factor for later mental health problems. A better understanding of such risk factors suggests the potential to *prevent* these problems. There is evidence from intervention studies such as Cognitive Bias Modification (CBM) training programmes that appraisal biases in response to intrusive memories can be modified (Lang et al., 2009; Woud, Postma, Holmes, & Mackintosh, 2013). Examples of more adaptive appraisals include ‘In a crisis, I predict my responses will be helpful’ or ‘intrusive memories mean nothing is wrong with me’ (Lang et al., 2009; Woud et al., 2012; Woud et al., 2013). Taking part in this type of CBM has been shown to reduce IES scores and the number of intrusive memories recorded in a diary following a stressful film fragment (Lang et al., 2009; Woud et al., 2012). With a stronger understanding of the link between cognitive control and intrusive or involuntary memory experience, it would be interesting to determine whether training cognitive control would have an impact on intrusive or involuntary memory experience.

In light of the already established importance of memory appraisals, in addition to looking at potential underlying deficits in cognitive control, the thesis also presented a novel intervention designed to address problematic reactions to intrusive memories. This was an important contribution to the literature, as there is a general lack of existing treatments focused on intrusive memories by individuals with depression (Newby et al., 2014). The intervention was based on mindfulness and self-compassion, and was predicted specifically to counteract negative appraisals and

ruminative self-deprecating responses to the memories, for example ‘I should be able to rid myself of this memory or ‘having this memory means I am inferior to other people’ (Moulds et al., 2008; Starr & Moulds, 2006; Williams & Moulds, 2008b). This is theoretically important given that it has been established that these maladaptive reactions to intrusive memories play a role in maintaining symptoms of depression longitudinally (Newby & Moulds, 2011c). Therefore, promoting a more adaptive, balanced and self-kind response through mindfulness and self-compassion training was predicted to be beneficial for participants. The intervention was compared to a control group who took part in relaxation training. This is an important addition to some previous research into mindfulness and self-compassion, which has only used waitlist control or treatment-as-usual control groups (Heeren & Philippot, 2011; Ma & Teasdale, 2004; Van Dam, Hobkirk, Sheppard, Aviles-Andrews, & Earleywine, 2014). Results were encouraging. There was a significant reduction in intrusive-memory distress, as measured by the IES, across both the mindfulness/self-compassion and relaxation groups. However, this reduction was not characterized by a larger decrease in distress in the mindfulness/self-compassion group as compared to the relaxation group. This outcome requires further clarification, after the limitations of the intervention study highlighted below have been addressed. More encouragingly, while there was a significant overall reduction in depressive symptomatology, as measured by the BDI-II, this was characterized by a significant decrease in BDI-II scores for the mindfulness/self-compassion group, and only a trend towards a significant reduction in BDI-II scores in the control group. This demonstrates that the intervention was particularly effective at reducing symptoms of depression. Finally, as predicted, only the mindfulness/self-compassion group reported significant increases on the measures of mindfulness and self-compassion.

These findings again demonstrate that the intervention was successful. However, there are some limitations to the study, beyond the low mood non-clinical sample used. This sample characteristic is subject to the same limitations as discussed earlier in the chapter. One potential problem could result from trying to operationalize or quantitatively measure mindfulness and self-compassion (Grossman, 2011). Both are traditionally Buddhist, rather than scientific, concepts (Baer, 2003; Kabat-Zinn, 1994), and one previously highlighted issue is the lack of specific definition of exactly what constitutes mindfulness (Grossman, 2011). This lack of clarity limits the ability to design an accurate measure of mindfulness, that stays true to its origins (Christopher, Charoensuk, Gilbert, Neary, & Pearce, 2009). While the concept of self-compassion has been more clearly defined (Neff, 2003a), it may also be difficult to empirically measure, because of its Eastern philosophical roots. Furthermore, many empirical investigations of mindfulness to date focus on *whether* the intervention is effective in reducing symptoms of a particular disorder, rather than focusing on *how* they are successful (Heeren & Philippot, 2011). For example, the first two large trial studies into the efficacy of MBCT on relapse into depression (Ma & Teasdale, 2004; Teasdale et al., 2000), and more recent examples including Kuyken et al. (2015), did not use self-report measures of mindfulness to assess changes in mindfulness. They instead focused directly on changes of psychopathology. However, as emphasized by Baer (2003), to ensure good evidence-based scientific practice, it is important to thoroughly assess whether the benefits of training do indeed result from the changes in mindfulness. One example of this type of analysis is Kuyken et al. (2010) who used the Kentucky Inventory of Mindfulness Skills (KIMS: Baer, Smith, and Allen (2004)) to determine that the changes in mindfulness and self-compassion mediated the effect of Mindfulness Based Cognitive Therapy (MBCT) on depression symptomatology,



with a sample size of 62. In their assessment of the Mindful Self-Compassion (MSC) intervention, Neff and Germer (2013) also measured changes in mindfulness and self-compassion. They used the Freiberg Mindfulness Inventory (Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006) and the SCS (Neff, 2003b) respectively. As previously discussed, this study found significantly larger increases on both measures in the MSC group (sample size = 25), as compared to the relaxation group (sample size = 27). These results suggest that the benefits observed following the intervention are indeed associated with changes in mindfulness/self-compassion processes. Accordingly, the current study used the Mindful Attention and Awareness scale (MAAS; Brown and Ryan (2003)) to assess changes between the two time points, rather than just looking at the impact of training on the intrusive memory, depression measures etc. The MAAS is one of the most common measures of mindfulness (Solloway & Fisher, 2007) and was chosen for the current study as it assesses the experience of mindfulness in daily life (Brown & Ryan, 2003). However, there are some limitations to the scale. Firstly, the MAAS only focuses on the attentional component of mindfulness (Bergomi, Tschacher, & Kupper, 2013). Other measures, such as the Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, and Toney (2006)) are based on a wider definition of mindfulness, and include aspects of non-judgement, non-reactivity and observing. As noted by Woodruff et al. (2014), the definition of mindfulness is somewhat dependent on the measure of mindfulness used. This is problematic in respect to the large variety of self-report measures of mindfulness, which include the MAAS, the KIMS, the Freiberg Mindfulness Inventory and the FFMQ described above, as well as the Philadelphia Mindfulness Scale (Cardaciotto, Herbert, Forman, Moitra, & Farrow, 2008). Contrary to the multiple measures of mindfulness, to my knowledge there is

only one validated measure of self-compassion, the Self-Compassion Scale (SCS), which was therefore the measure used in this intervention study. Another limitation of the MAAS is that items are expressed in terms of what is *not* mindful, e.g. ‘I find myself doing things without paying attention’ and ‘I tend not to notice feelings of physical tension or discomfort until they really grab my attention’. This wording is slightly contradictory to the acceptance and non-judgemental aspect of mindfulness (Kabat-Zinn, 1994). In addition to the potential limitations of once specific scale, there are also more general issues pertaining to the use of self-report measures of mindfulness. It is unclear whether we are able to accurately assess our level of mindfulness; it may not be something we are familiar with noticing and answering questions about (Baer, 2011; Grossman, 2011). While this is addressed to some extent through the use of statements written in ordinary language which do not require any prior knowledge of mindfulness to interpret (Baer, 2011), for example ‘I rush through activities without being attentive to them’ (Brown & Ryan, 2003), there still may a problem of validity. Furthermore, participants may be especially motivated to report changes on the questionnaires after putting substantial time and effort into a mindfulness intervention (Grossman, 2011). These factors may have impacted the ability to accurately measure mindfulness in the present intervention study.

In addition to addressing these methodological limitations, recommendations for the future direction of the intervention study will now be presented. For example, it is important to establish the longevity of the reductions in intrusive-memory distress and BDI-II scores that were found in the current study. There is some initial evidence that reductions in psychopathology are sustainable, for both mindfulness (Kuyken et al., 2008; Ma & Teasdale, 2004) and self-compassion (Neff & Germer, 2013) based

interventions. However, it is crucial to establish whether this is also the case for a *short* mixed intervention, as some of the other short interventions that have been tested did not include a follow-up period (Cavanagh et al., 2013; Smeets et al., 2014). As both mindfulness and self-compassion training involve quite substantial changes in the way individuals relate to emotional adversity, achieving sustainable changes may require a minimum number of sessions to promote long-term changes. Another issue for future research concerns the exact make-up of the intervention. In my thesis, I chose to use a two-component intervention for two reasons. Firstly, as discussed, while mindfulness and self-compassion share some similarities, it was proposed that both components would bring specific benefits to participants, as individuals have been shown to react both unmindfully ('Because I've had this intrusive memory, what I'm doing will be ruined') and in a non self-compassionate manner ('Because I can't control these memories, I am a weak person') to their intrusions (Moulds et al., 2008). Therefore targeting both processes at once was expected to be more effective than addressing either one on their own. Moreover, Neff (2003a) proposes that mindfulness training is an important prerequisite of self-compassion training. Specifically, to be self-compassionate, individuals need to not overreact to or suppress negative thoughts, memories or feelings. These are skills that participants gain through mindfulness practice. Despite this underlying rationale, it is important to determine whether either of the two components is particularly successful at reducing intrusive-memory distress, or whether the combination of the two processes is the most effective. Furthermore, if indeed it is the combination that is the most beneficial, it would be important to establish the optimal configuration of sessions. For example, it is essential to establish whether equal numbers of sessions in mindfulness and self-compassion are the most beneficial, rather than the current design which consisted of

two mindfulness sessions and only one self-compassion session. Another avenue for future research is to establish whether the improvements that were observed would also be found in a clinical sample. To my knowledge, there are no published investigations of a *mixed* mindfulness and self-compassion intervention in a clinical sample. Mindfulness and self-compassion both have been associated with reductions in psychopathology in clinical samples (Gilbert & Procter, 2006; Heeren & Philippot, 2011; Ma & Teasdale, 2004; Teasdale et al., 2000) but as previously discussed, in the case of MBCT, the training was not effective across the whole sample (Ma & Teasdale, 2004; Teasdale et al., 2000). While more general mindfulness interventions have been shown to be effective in wider samples, such as community and student samples (Cavanagh et al., 2013; Danitz & Orsillo, 2014; Erogul et al., 2014; Shapiro et al., 1998), it remains to be determined whether a mixed intervention would only be effective for certain people, for example people with particularly low levels of mindfulness or self-compassion at baseline, or individuals with an extensive history of depression. Nonetheless, despite the limitations of this initial investigation, results are encouraging and the study is a first step towards addressing the current lack of treatment for intrusive memories in depression (Newby et al., 2014). This is an important contribution to the literature.

Another goal of this thesis was to consider the overall manifestations of involuntary memory within the context of depression, when looking at the potential importance of individual differences in cognitive control. Recently, researchers have emphasized the importance of considering the research on involuntary memories more generally when looking at intrusive memories, instead of assuming intrusive memories are trauma-specific or always problematic (Berntsen, 2011; Moulds & Krans, 2015). However,

this research is still in its infancy. It is important to bridge the gap between the two avenues of research because it has been demonstrated that dysphoric and depressed individuals experience both negative involuntary and positive involuntary memories, in both laboratory and diary studies (Kvavilashvili & Schlagman, 2011; Watson et al., 2012). Therefore, only focusing on *intrusive* memories is overlooking other potentially important aspects of depressive cognition. As a consequence of this narrow focus, one important matter that had not gained a great deal of research attention is the relationship between the valence of involuntary memories and mental health problems. For example, it is unclear whether it is the case that low mood individuals experience more negative memories and/or fewer positive memories, or whether there is no association between the valence of involuntary memories and symptoms of depression. Consequently, chapter five sought to address this lack of research by looking at the relationship between the proportion of negative involuntary memories and the proportion of positive involuntary memories experienced in association with BDI-II scores. However, in this student and community sample, there were no significant correlations between memory valence (as rated by participants) and BDI-II scores. Participants with higher BDI-II scores did not record more negative, or fewer positive involuntary memories on the diary measure. Nonetheless, this finding may be a result of the non-clinical sample tested, as it must be noted that participants' mean BDI-II score was relatively low (mean = 9.23, SD = 5.65). This might have resulted in insufficient variance to reveal significant correlations. It would therefore be helpful for future research to look at samples with higher levels of depressive symptomatology. Another possibility would be to compare the mean valence of the memories and the proportions of memories experienced by currently depressed, recovered depressed and never depressed individuals, as categorized

through the Structured Clinical Interview for DSM-IV disorders (SCID-I; First, Spitzer, Gibbon, and Williams (2002)). This would indicate whether depressed individuals experience more negative and/or fewer positive, involuntary memories as compared to recovered depressed or never depressed individuals. As argued throughout the thesis, it is also possible that certain samples *react* to their memories differently, rather than it necessarily being the case that they experience different numbers of positive or negative memories in the first place. This is supported by work by Kvavilashvili and Schlagman (2011) who found that dysphoric participants rated their involuntary memories for negative events as more unpleasant than non-dysphoric participants, although the events were not objectively more negative, as rated by the researchers. This suggests that negative cognitive biases played a role in the memory ratings for the dysphoric participants and demonstrates a parallel between voluntary and involuntary memory systems (Watson et al., 2013). On the other hand, their dysphoric participants did report *fewer* memories for positive events, as rated by the researcher. However, with a correlational analysis, this reduced experience of positive involuntary memories as a function of low mood was not replicated in the diary study presented in chapter five, which is a more naturalistic setting than a laboratory vigilance task. It is important to continue to investigate the relationship between depressive symptomatology and involuntary memory valence in a sample with higher numbers of dysphoric, as well as clinically depressed, participants. This is because, as previously argued in the thesis, the cognitive biases in depressed mood that have been shown to affect voluntary memory, including higher recall of negative material or difficulty recalling positive material (Mathews & MacLeod, 2005), are well established. However, much less is known about the potential effect of these biases in terms of involuntary memories (Watson et al., 2012). For example, very

little work has investigated the impact of reactions to non-intrusive involuntary memories, for example reactions to positive involuntary memories. However these memories potentially have a negative impact on mood. For example, it has been shown that analytical responses to positive voluntarily recalled memories (e.g. thinking about the causes, meanings and consequences of the event) in low mood samples can result in decreases in mood (Werner-Seidler & Moulds, 2012; Werner-Seidler, 2014). It remains unclear whether this may also be the case for *involuntarily* recalled positive memories. If, however, vulnerable individuals were shown to endorse maladaptive appraisals or ruminative reactions to positive involuntary memories (e.g. ‘why can’t things be this good now?’), this may be a good target for the treatment of mood disorders. This speaks to the importance of continuing to look at the overall experience of involuntary memories in low mood and depressed samples, rather than focusing only on ‘traditional’ intrusive memories. To my knowledge, the work presented in this thesis reflects one of the initial attempts to address this.

In conclusion, the current programme of research makes important contributions to the existing literature on intrusive and involuntary memories. The research was motivated by existing research demonstrating that individual differences in cognitive control are associated with the experience of these intrusive memories (Verwoerd et al., 2009; Verwoerd et al., 2011; Wessel et al., 2010), and represented the first application of the DMC, an important framework in the cognitive control literature, to this specific research question. Another important contribution to the literature was the use of an emotional task of cognitive control in the final study. Overall, there was some indication that individuals experiencing a high number of negative involuntary

memories are characterized by a deficit in proactive control. This was the case for diary measures of negative involuntary memories, on both the classic and emotional variant of the AX-CPT, and for the measure of intrusive-memory related distress on the emotional AX-CPT. These findings demonstrate that there is some link between cognitive control and the experience of memories concerning negative events that come to mind without being deliberately recalled. However, particularly in the final study, not all findings were clear-cut or in the predicted direction, therefore the link between cognitive control and intrusive memory experience needs to be further clarified. The work presented in the thesis reflects a step forward in this direction. In light of recent criticism of the lack of interaction between the involuntary and clinically-focused intrusive memory literatures (Moulds & Krasner, 2015), the current thesis also extended the existing cognitive control work to investigate whether there was a link between the overall experience of involuntary memories, irrespective of the valence of the memory, and individual differences in cognitive control. In addition, as previously argued, individuals may react in a negative way to positive involuntary memories, such as has been demonstrated in reaction to positive voluntary memories (Joormann & Siemer, 2004; Joormann, Siemer & Gotlib, 2007). However, there were no differences on the task between individuals who reported experiencing a high number of involuntary memories and individuals who reported low numbers of these memories. This null finding suggests that individuals experiencing high numbers of involuntary memory are not characterized by a deficit in cognitive control. Another novel contribution of the thesis was the demonstration that a brief mindfulness and self-compassion based intervention significantly reduced the distress associated with intrusive memories in a low mood sample. In addition, both the mindfulness/self-compassion intervention and the relaxation control group reported reductions in



depressive symptomology, as measured by the BDI-II. The intervention was therefore successful and results suggest the potential for the development of intrusive-memory treatment. This is important because intrusive memories have been associated with the maintenance of depressive symptomatology longitudinally (Newby & Moulds, 2011b) and therefore are an important target for treatment. In sum, the present thesis has demonstrated the importance of proactive control related-deficits on intrusive or negative involuntary memory experience, and the importance of specifically encouraging participants to react more mindfully and more self-compassionately to their intrusive memories to reduce both distress and symptoms of depression.

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## Appendix A

### Example Diary Questions

Diary questions: (to be completed for each intrusive memory experienced)

What were you doing when the memory came to mind?

Were you thinking anything at the time?

How was your mood?

Very good      0      1      2      3      4      5      Very bad

Describe the memory in detail:

Is the memory characterized by a certain emotional content?

Hardly negative      1      2      3      4      5      Extremely negative

Did the memory influence your mood?

My mood became better, worse, uninfluenced (please circle)

Diary questions (to be completed for each involuntary memory experienced)

What were you doing when the memory came to mind?

Were you thinking anything at the time?

How was your mood?

Very good      0      1      2      3      4      5      Very bad

Describe the memory in detail:

Is the memory characterized by a certain emotional content?

Very negative      0      1      2      3      4      5      Very positive

Did the memory influence your mood?

My mood became better, worse, uninfluenced (please circle)

## Appendix B

### Compliance Questionnaire

*Please answer the questions below as honestly as possible.*

*For all questions: 1=I completely agree, 5=I completely disagree*

**Question 1:** I wrote down every negative involuntary memory I experienced over the 7 days

1            2            3            4            5

**Question 2:** There were times I experienced a negative involuntary memory but I couldn't put it into words

1            2            3            4            5

If so, how many times do you estimate this was the case.....

**Question 3:** There were many times I experienced a negative involuntary memory but it was impractical to record details of the memory

1            2            3            4            5

If so, how many times do you estimate this was the case.....

**Question 4:** Overall, the number of memories recorded in my diary reflects very well the number of negative involuntary memories I experienced over the week

1            2            3            4            5



## Appendix C

### Ethical Approval Forms

#### Study one



University of St Andrews

University Teaching and Research Ethics Committee

7 December 2011

<b>Ethics Reference No:</b> <i>Please quote this ref on all correspondence</i>	PS8267
<b>Project Title:</b>	Self-Compassion training to reduce negative experience associated with Intrusive Memories in depression
<b>Researcher's Name:</b>	Stephanie Hunter
<b>Supervisor:</b>	Dr Barbara Dritschel

Thank you for submitting your application which was considered at the Psychology School Ethics Committee meeting on the 29<sup>th</sup> November 2011. The following documents were reviewed:

- |                                  |            |
|----------------------------------|------------|
| 1. Ethical Application Form      | 05/12/2011 |
| 2. Advertisements                | 05/12/2011 |
| 3. Participant Information Sheet | 05/12/2011 |
| 4. Consent Form                  | 05/12/2011 |
| 5. Debriefing Form               | 05/12/2011 |
| 6. Interview and Scales          | 05/12/2011 |

The University Teaching and Research Ethics Committee (UTREC) approves this study from an ethical point of view. Please note that where approval is given by a School Ethics Committee that committee is part of UTREC and is delegated to act for UTREC.

Approval is given for three years. Projects, which have not commenced within two years of original approval, must be re-submitted to your School Ethics Committee.

You must inform your School Ethics Committee when the research has been completed. If you are unable to complete your research within the 3 three year validation period, you will be required to write to your School Ethics Committee and to UTREC (where approval was given by UTREC) to request an extension or you will need to re-apply.

Any serious adverse events or significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the School Ethics Committee, and an Ethical Amendment Form submitted where appropriate.

Approval is given on the understanding that the 'Guidelines for Ethical Research Practice' (<http://www.st-andrews.ac.uk/media/UTRECguidelines%20Feb%2008.pdf>) are adhered to.

Yours sincerely

Convenor of the School Ethics Committee

Ccs Dr Barbara Dritschel (Supervisor)  
School Ethics Committee

### 1. Candidate's declarations:

I, Stephanie Sayan, hereby certify that this thesis, which is approximately 70,000 words in length, has been written by me, and that it is the record of work carried out by me, or principally by myself in collaboration with others as acknowledged, and that it has not been submitted in any previous application for a higher degree.

I was admitted as a research student in September 2011 and as a candidate for the degree of PhD in September 2011; the higher study for which this is a record was carried out in the University of St Andrews between 2011 and 2015.

Date 31/7/15 signature of candidate

### 2. Supervisor's declaration:

I hereby certify that the candidate has fulfilled the conditions of the Resolution and Regulations appropriate for the degree of PhD in the University of St Andrews and that the candidate is qualified to submit this thesis in application for that degree.

Date 31/7/15 signature of supervisor

### 3. Permission for publication: (to be signed by both candidate and supervisor)

In submitting this thesis to the University of St Andrews I understand that I am giving permission for it to be made available for use in accordance with the regulations of the University Library for the time being in force, subject to any copyright vested in the work not being affected thereby. I also understand that the title and the abstract will be published, and that a copy of the work may be made and supplied to any bona fide library or research worker, that my thesis will be electronically accessible for personal or research use unless exempt by award of an embargo as requested below, and that the library has the right to migrate my thesis into new electronic forms as required to ensure continued access to the thesis. I have obtained any third-party copyright permissions that may be required in order to allow such access and migration, or have requested the appropriate embargo below.

The following is an agreed request by candidate and supervisor regarding the publication of this thesis:

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Embargo on all or part of electronic copy for a period of 1 year on the following ground(s):

- Publication would preclude future publication

### Supporting statement for electronic embargo request:

Research has not yet been published

Date 31/7/15 signature of candidate

signature of supervisor



## Study two



University of St Andrews

University Teaching and Research Ethics Committee

11 September 2012

<b>Ethics Reference No:</b> <i>Please quote this ref on all correspondence</i>	PS9131
<b>Project Title:</b>	Cognitive control and intrusive memories in depression
<b>Researcher's Name:</b>	Steph Hunter
<b>Supervisors:</b>	Dr Barbara Dritschel and Dr Ines Jentzsch

Thank you for submitting your application which was considered at the Psychology & Neuroscience School Ethics Committee meeting on the 3<sup>rd</sup> August 2012. The following documents were reviewed:

- |  |            |
|--|------------|
| 1. Ethical Application Form              | 11/09/2012 |
| 2. Participant Information Sheet         | 11/09/2012 |
| 3. Consent Form                          | 11/09/2012 |
| 4. Debriefing Form                       | 11/09/2012 |
| 5. Advertisement                         | 11/09/2012 |
| 6. Interview, Scales and Diary Questions | 11/09/2012 |

The University Teaching and Research Ethics Committee (UTREC) approves this study from an ethical point of view. Please note that where approval is given by a School Ethics Committee that committee is part of UTREC and is delegated to act for UTREC.

Approval is given for three years. Projects, which have not commenced within two years of original approval, must be re-submitted to your School Ethics Committee.

You must inform your School Ethics Committee when the research has been completed. If you are unable to complete your research within the 3 three year validation period, you will be required to write to your School Ethics Committee and to UTREC (where approval was given by UTREC) to request an extension or you will need to re-apply.

Any serious adverse events or significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the School Ethics Committee, and an Ethical Amendment Form submitted where appropriate.

Approval is given on the understanding that the 'Guidelines for Ethical Research Practice' (<http://www.st-andrews.ac.uk/media/UTRECguidelines%20Feb%2008.pdf>) are adhered to.

Yours sincerely

 Convenor of the School Ethics Committee

Ccs Dr B. Dritschel (Supervisor)  
Dr I. Jentzsch (Supervisor)  
School Ethics Committee

UTREC Convenor, Mansefield, 3 St Mary's Place, St Andrews, KY16 9UY  
Email: [utrec@st-andrews.ac.uk](mailto:utrec@st-andrews.ac.uk) Tel: 01334 462866  
The University of St Andrews is a charity registered in Scotland: No SC013532

## Study three



University of St Andrews

University Teaching and Research Ethics Committee

20 March 2013

<b>Ethics Reference No:</b> <i>Please quote this ref on all correspondence</i>	PS9653
<b>Project Title:</b>	Cognitive Control and Involuntary Memory
<b>Researcher's Name:</b>	Steph Hunter
<b>Supervisors:</b>	Dr Barbara Dritschel and Dr Ines Jentzsch

Thank you for submitting your application which was considered at the Psychology & Neuroscience School Ethics Committee meeting on the 27<sup>th</sup> February 2013. The following documents were reviewed:

1. Ethical Application Form	08/03/2013
2. Advertisement	08/03/2013
3. Participant Information Sheet	08/03/2013
4. Consent Form	08/03/2013
5. Debriefing Form	08/03/2013
6. Questionnaires	08/03/2013

The University Teaching and Research Ethics Committee (UTREC) approves this study from an ethical point of view. Please note that where approval is given by a School Ethics Committee that committee is part of UTREC and is delegated to act for UTREC.

Approval is given for three years. Projects which have not commenced within two years of original approval must be re-submitted to your School Ethics Committee.

You must inform your School Ethics Committee when the research has been completed. If you are unable to complete your research within the three year validation period, you will be required to write to your School Ethics Committee and to UTREC (where approval was given by UTREC) to request an extension or you will need to re-apply.

Any serious adverse events or significant changes which occur in connection with this study, and/or which may alter its ethical consideration, must be reported immediately to the School Ethics Committee and an Ethical Amendment Form submitted where appropriate.

Approval is given on the understanding that the 'Guidelines for Ethical Research Practice' (<http://www.st-andrews.ac.uk/media/UTRECguidelines%20Feb%2008.pdf>) are adhered to.

Yours sincerely

Convenor of the School Ethics Committee

Ccs Dr B. Dritschel (Supervisor)  
Dr I. Jentzsch (Supervisor)  
School Ethics Committee

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Email: [utrec@st-andrews.ac.uk](mailto:utrec@st-andrews.ac.uk) Tel: 01334 462866  
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## Study four



University of St Andrews

University Teaching and Research Ethics Committee  
Sub-committee

28 February 2014

<b>Ethics Reference No:</b> <i>Please quote this ref on all correspondence</i>	PS10857
<b>Project Title:</b>	Cognitive Control and experience of intrusive memories
<b>Researcher's Name:</b>	Steph Sayan
<b>Supervisors:</b>	Dr Barbara Dritschel and Dr Ines Jentzsch

Thank you for submitting your application which was considered at the Psychology & Neuroscience School Ethics Committee meeting on the 26<sup>th</sup> February 2014. The following documents were reviewed:

1. Ethical Application Form	28/02/2014
2. Advertisement	28/02/2014
3. Participant Information Sheet	28/02/2014
4. Consent Form	28/02/2014
5. Debriefing Form	28/02/2014
6. Intrusive Memory Interview	28/02/2014
7. Questionnaires	28/02/2014
8. BDI Protocol	28/02/2014
9. Data Management Plan	28/02/2014

The University Teaching and Research Ethics Committee (UTREC) approves this study from an ethical point of view. Please note that where approval is given by a School Ethics Committee that committee is part of UTREC and is delegated to act for UTREC.

Approval is given for three years. Projects, which have not commenced within two years of original approval, must be re-submitted to your School Ethics Committee.

You must inform your School Ethics Committee when the research has been completed. If you are unable to complete your research within the 3 three year validation period, you will be required to write to your School Ethics Committee and to UTREC (where approval was given by UTREC) to request an extension or you will need to re-apply.

Any serious adverse events or significant change which occurs in connection with this study and/or which may alter its ethical consideration, must be reported immediately to the School Ethics Committee, and an Ethical Amendment Form submitted where appropriate.

Approval is given on the understanding that the 'Guidelines for Ethical Research Practice' <https://www.st-andrews.ac.uk/utrec/guidelines/> are adhered to.

Yours sincerely

Convener of the School Ethics Committee

Ces Dr B. Dritschel (Supervisor)  
Dr I. Jentzsch (Supervisor)  
School Ethics Committee

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